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Toward Sustainable Diets

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Photo by Samantha Farquhar, corresponding author

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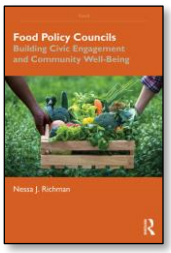

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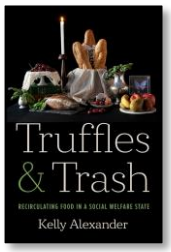

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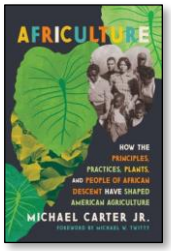

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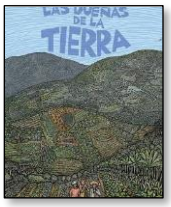

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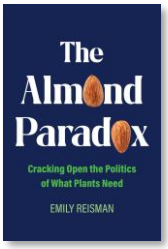

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IN THIS ISSUE
DUNCAN HILCHEY

Toward sustainable diets

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In this issue, we explore the emerging food systems subfield of sustainable diets, with a focus on community needs and aspirations, especially among vulnerable populations. First coined by Gussow and Clancy (1986), the JAFSCD Sustainable Diets Editorial Circle (SDEC) defines the term *sustainable diets* as dietary patterns that promote individual and population health and well-being while having low environmental impacts; are culturally affirming, affordable, safe, nutritionally robust, and attainable for all; and contribute to resilient, equitable, and sustainable food systems for present and future generations. This definition is adapted from the Food and Agriculture Organization of the United Nations and the World Health Organization (FAO & WHO, 2019).

Reflecting the **sustainable diets** theme, our cover features community members in Nunavik, Northern Québec, Canada, mapping food sources and pathways and exploring household food-access decisions under

Duncan Hilchey, MRP, is editor-in-chief and publisher of the *Journal of Agriculture, Food Systems, and Community Development*, published by the Thomas A. Lyson Center for Civic Agriculture and Food Systems; duncan@lysoncenter.org; https://orcid.org/0000-0001-9465-6606

AI Use Declaration
I produced this editorial with assistance from ChatGPT (ver. GPT-5.5) to analyze themes and improve syntax and grammar.

On Our Cover
Community members from Nunavik, in Northern Québec, Canada, participate in a workshop focused on mapping the community food system. Each group was asked the question, "Where does a typical Inuk household get food?" Then members drew arrows showing the flow of food resources into the household. Next, these food pathways were explored through scenarios to understand household decision-making. Members were given blue "order" cards with numbers and asked to label where in the food system a household would seek food based on the situation; for example, "What is the first place, second place, third place, etc., a typical Inuk household would seek food if the household had low income and the community freezer was broken?" Read more in the article in this issue, Challenges and complexities in Northern food systems: Mapping food access and decision-making in Nunavik. *Photo by Samantha Farquhar, corresponding author*

different scenarios. Read more in *Challenges and complexities in Northern food systems: Mapping food access and decision-making in Nunavik* by Samantha Farquhar and colleagues.

We begin this issue with a several substantive preliminaries. In his Economic Pamphleteer column, *Breaking the cycles of co-optation*, **John Ikerd** considers how taxpayer-supported industrialization continues to shape food systems and calls for place-based restoration and regeneration facilitated by trust between local farmers and consumers. This is followed by JAFSCD Associate Editor of Value Chain Coordination **Anaya Hall**'s column, *Bridging margin and mission*, in which she cogently argues that a "mission without a viable value chain" will not survive. Next, we offer our inaugural Sustainable Diets brief, entitled *Produce prescription programs: An innovative strategy for improving healthy food access*, in which **Sara Shostak**, **Jolie Black**, and **Stacey Daley** examine how produce prescription programs can improve access to healthy food. See the standalone brief at the JAFSCD website.[1] I would like to take this opportunity to express our appreciation to JAFSCD Associate Editors **Kathleen Kevany** and **Allison Lansman** for their leadership in publishing this first sustainable diets brief.

Topping off our preliminaries, we have two viewpoints: in *Emancipatory scaling: Strengthening locally led AR4D innovation processes*, **Hanna Ewell**, **Inez Dekker**, **Jon Hellin**, **Dagmawi Abegaz Melaku**, **Esther Milberg Muñiz**, **Samuel Mugambi**, **Philipp Neudert**, **Ebenezer Ngissah**, and **Daphne Schoop** introduce us to the concept of "emancipatory scaling," which privileges full participation and co-control over simply having bigger and broader impact. And in a second viewpoint, *Sub-Saharan Africa is experiencing a food-related health risk problem in informal food environments: An urgent need for science and policy actions*, **Richard Nyiawung**, **Joachim Matondo**, **Anastazia Bikuba**, **Victoria Ndinelago Erasmus**, **Evodius Rutta**, **Rosemary Tegekanya**, **Shirley Kansabe**, **Gery Wamba**, **Neville Suh**, **Norbert Ngwang**, **Samuel Abalansa**, **Md. Ruyel Miah**, and **Abdul-Rahim Abdulai** examine food safety risks in local food environments and the dire need for more research and policy interventions.

Our first few open call papers are focused on vulnerable demographic groups. *In Challenges and complexities in Northern food systems: Mapping food access and decision-making in Nunavik*, **Samantha Farquhar**, **Sonagnon Olivier Tokpanou**, **Frédéric Maps**, **Tiff-Annie Kenny**, **Marianne Falardeau**, **Duncan Warltier**, **Eric Wade**, **Rebbeca Asch**, **Martin Cenek**, **Jon Kirchoff**, and **Nadine Heck** share a participatory method of mapping food access and decision-making in Nunavik, Quebec, Canada. And in *Sociodemographic correlates of food security status among older adults in central Ohio: Toward a typology of risk*, **Lauren Roberson**, **Katie Simpson**, **Michelle Kaiser**, **Smitha Rao**, **Holly Dabelko-Schoeny**, **Marisa Sheldon**, and **Allison Heemer** identify key demographic characteristics associated with food insecurity among seniors in central Ohio. **Curtis Antrum**, **Violeta Chacón**, **Kim Gans**, **Molly Waring**, **Ran Xu**, **Maria Gombi Vaca**, and **Caitlin Caspi** then develop a profile of the characteristics associated with first-time users of charitable community food resources during the COVID-19 pandemic in their paper, *Identifying characteristics of first-time use of charitable community food resources during the COVID-19 pandemic*. And in *"I don't say food desert, I say food apartheid": Community-engaged research to understand food insecurity*, **Ange Asanzi**, **Miranda Martin**, **Alicia Papanek**, **Damilola Ajayi**, **Acquel Allen-Mitchell**, **Tristesse Burton**, **Brittney Dixon**, and **Paul Monaghan** use community-engaged research to understand the lived reality of people experiencing food insecurity in a predominantly African American community. Broadening the sustainable diets lens beyond these North American cases, **Agus Fitriangga**, **Alex**, **Agustina Arundina Triharja Tejoyuwono**, **Efriani**, **Dedy Ari Asfar**, and **Yusriadi** explore how local provisioning in a rural Indonesian community serves as a crucial buffer against nutritional and economic shortages in their paper *Indigenous vegetables and household food security in a borderland community: Evidence from the Dayak Bidayuh of Entikong, Indonesia*.

Shifting to a focus on universities, **Lana Petrie**, **Rick Rudd**, **Sarah Misyak**, **Karen Eley Sanders**, **Van**

[1] https://doi.org/10.5304/jafscd.briefs.sdb01

Crowder, and **Logan Layne** explore how food access has a major impact on students' quality of life in *Student voices: A mixed-method approach to understanding the quality of life of students living with food access barriers*. In a complementary study of college food insecurity entitled *Understanding college food insecurity through the lens of the theory of planned behavior and social stigma*, **Brianna Mallozzi**, **Manan Roy**, **Alisha Farris**, **Alisa Duong**, and **Ayron Walker** explore why students may not use campus-based food pantries. Next, at the institutional level, **Victor Olayemi**, **Chanita Holmes**, **Ralph Hall**, **Elena Serrano**, **Samantha Harden**, and **Sarah Misyak** explore the troubling irony of food insecurity among a subset of college-level professionals in *Estimates of food insecurity among Cooperative Extension employees at a southeastern land-grant university*.

Continuing with our sustainable diets theme, we offer several papers addressing food waste. In *Association between nutrition assistance programs and household produce waste during the COVID-19 pandemic*, **Akiko Hosler**, **Heather Duncan**, **Beth Feingold**, **Xiaobo Romeiko**, **Christine Bozlak**, **Jiacheng Chen**, **Mariana Torres Koutsopoulos**, and **Tianghon Mu** explore the potential to reduce food waste while improving access to fresh produce. Next, in their research brief *Make every bite count: Can reduced food waste sustain free school meals in South Carolina?*, **Qi Jiang**, **Alba Collart**, **Felipe de Figueiredo Silva**, and **Yefan Nian** find that potential savings from food waste reduction could help offset costs and sustain crucial school meal programs. Finally, **Kaitlyn Harper**, **Steffanie Espat**, **Lee Davis**, **Nicole Labruto**, and **Roni Neff** share the views of frontline grocery store workers on reducing waste while increasing donations to charitable organizations in *Formative research on strategies to improve food donation in grocery retail*.

Following sustainable diets, we turn to food system planning. In *Future-proofing the regional foodshed: Evaluating the supply of off-season produce to feed a city*, **Sara Elton**, **Kelly Gregory**, and **Marina Queirolo** explore the capability of the City of Toronto to protect its food security and sovereignty during an era of political turbulence. Next, in their paper *Regional food system resilience and rural realities,* **Lia Kelinsky-Jones** and **Jessica Spence** find that while individual local efforts can be effective in food system development, in the case of Appalachia, more cross-jurisdictional planning is needed to achieve broader, longer-term impact. **Julianna Nieuwsma**, **Leslie Cofie**, **Elisabeth Reed**, **Jamie Bloss**, **Emery Harwell**, **Roger Russell**, **Joseph Lee**, and **Catherine LePrevost** then share the frustration of farmers in North Carolina regarding the lack of broadband and its likelihood to hamper agricultural development in their paper *"We use it … and we need it now": An assessment of internet and technology use among farm owners and managers*. In *Building protective data infrastructure for urban community gardens: Lessons from the Philadelphia Garden Data Collaborative*, **Peleg Kremer**, **Craig Borowiak**, and **Madeline Scolio** explore the value and limitations of gathering garden data, as well as the need for more proactive protections for these precarious spaces. Next, in *Criteria for selecting assessment tools for local food systems in the context of socio-ecological transitions*, **Antsatiana Jésuelle Rabialahy**, **Laurence Guillaumie**, **Marie-Ève Gaboury-Bonhomme**, and **Laure Saulais** examine indicator criteria and the pros and cons of various impact measures. And in *Audited engagement: Making agri-food community development "count" in higher education and beyond*, **Michael Carolan** shares his vision for more emphasis on formally measuring community engagement beyond the scale and scope of involvement, and more toward the actual impact of that involvement.

We continue with several food system planning papers from Europe. In *Municipal food systems planning in Sweden Barriers, enablers, and the role of regional collaboration*, **Malin Andersson**, **Madeleine Granvik**, and **Rebecka Milestad** identify the valuable role of "food champions" in promoting internal and external collaboration. Taking a broader land-use perspective, *Navigating the nexus of food, energy, and ecology: Foodshed approaches for integrated land use policies*, **Tanja Strobel-Unbehaun** and **Peter Breunig** use a modified version of Metropolitan Foodshed and Self-sufficiency Scenario (MFSS) to find, among other things, that biofuel production (as opposed to wind and photovoltaic systems) competes with local food self-sufficiency by taking land for human consumption out of production. And in *Connecting local food system actors for climate-friendly public catering in Germany Lessons learned from a transformative and transdisciplinary research project*, **Annika Fricke**,

Franziska Bürker, **Pia Laborgne**, **Sarah Meyer-Soylu**, and **Eva Wendeberg** share lessons from their study of institutional cafeterias, identifying key barriers such as the cost of obtaining organic certification to the producer and the acceptance of vegan or vegetarian options by consumers.

Next, we turn to food value or supply chains. In *Scaling local food: A literature review on the organization, benefits, and challenges of food hubs*, **Simone Ubertino** and **Patrick Mundler** study the literature to identify the persistent issues associated with food hub viability, specifically farmer coordination, institutional market stability, and financial resilience. Next, in their paper *Challenges and barriers in food supply chains: A scoping review of needs assessments in the southern border counties of Texas and New Mexico*, **Juan Aguilera**, **Perla Alarcon**, **Ogochukwu Abasilim**, **Cristina Dominguez**, **Leah Whigham**, **Gabriela Gallegos**, and **Elizabeth Racine** find climate issues, infrastructure, and market access, among other factors, making it difficult for small and midscale farmers in the southern U.S. borderlands. This is followed by **Gaudy Solorzano-Morera**, **Elizabeth Durango-Cohen**, and **Weslynne Ashton,** who identify the tension between the intentions of values-based supply chains and the engagement of their intended beneficiaries in *Minding the implementation gap: A mixed-method study of producer capabilities and institutional pressures in U.S. Midwest values-based food procurement*. And in *From fields to markets: Diversification case studies in the U.S. Corn Belt via a social-ecological systems lens*, **Katherine Pivaral Toledo**, **Brennan Radulski**, **Ariana Torres**, **Laura Esman**, and **Linda Prokopy** use the SES framework to explore the drivers and barriers to diversification in the Midwest.

Turning to value chains in the Global South, in *Toward resilient agrifood institutions: Evaluating farmer corporations in the context of shallot value chains in Indonesia*, **Afrizal Malik**, **Yayat Hidayat**, **Anggi Sahru Romdon**, **Ratih Kurnia Jatuningtyas**, **Moh. Saeri**, **Yusuf**, **Nurmalinda**, **Yopi Saleh**, **Dedi Sugandi**, **Nur Qomariah Hayati**, **Joko Triastono**, **Bahtiar**, **Nelson Hasdy Kario**, **Intan Gilang Cempaka**, **Raden Heru Praptana**, **Seno Basuki**, **Dadan Ramdhani Nugraha**, **Dinar**, **Jaka Sulaksana**, and **Sri Ayu Andayani** find that these unique groups provide effective collective bargaining power for independent growers. Conversely, in *Why do producers decide not to join agricultural associations? The case of the Ataulfo mango in southern Mexico*, **Luis Sumuano-Barragán**, **Juan Barrera**, **Jorge Toledo**, **Obeimar Herrera-Hernández**, and **Pablo Liedo** examine why some producers do not engage in collective action organizations and yet still manage to succeed. And in the Ecuadorian Amazon, *Opportunity costs and agricultural transformation in the Ecuadorian Amazon: Cacao cultivation in traditional Shuar systems*, **Byron Moyano**, **Ronald León**, **Víctor Hernández-Aranda**, **Galo Cedeño García**, **Ángel Cedeño Sacón**, **Carlos Arias-Vega**, **Marcos Vera-Morales**, **David Catagua**, **Zoila Cruz-Burga**, **Lizardo Reyna Bowen**, **Sheena Sangay-Tucto**, and **Leonardo León-Castro** identify the needs of traditional farms to become sustainable, including agroforestry practices, credit, and ecologically appropriate planting materials.

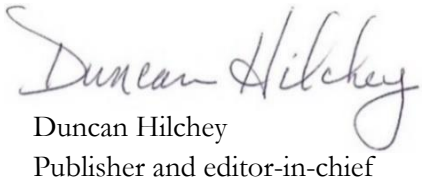
In our last group of papers, we turn to workforce-related issues. In their study *Social, cultural, political, and human capital perceptions by young food system professionals*, **Beatrice Nyarko**, **David Conner**, **Meghan Cope**, and **Kate Mays** use the community capitals framework to explore the views of the next generation of food system professionals in the state of Vermont. In *Bridging cultural divides: Culture and acculturation in Latino/a service-provider interactions*, **Ervin Leiva**, **Corinne Valdivia**, and **Stephen Jeanetta** find that weak cultural connections between Latin/a farmers and agencies and institutions are barriers to small and midscale agriculture development in the state of Missouri. Next, **Karie Boone**, **Sonia Hall**, **Chad Kruger**, **Bernardita Sallato C.**, and **Georgine Yorgey** identify the surprising factors limiting the effectiveness of farmworker support organizations in Eastern Washington State in *Planning for the "new normal": Farmworker support organizations' experiences of climate change impacts and adaptation*. The language barrier is further explored in *Assessment of needs for produce safety educational resources for non–English-speaking growers in the Midwest*, by **Angelina Adjetey**, **Sagar Pokhrel**, **Manreet Bhullar**, **Londa Nwadike**, **Melissa Cater**, **Shuyang Qu**, and **Shannon Coleman.** A further food-safety perspective comes from *Urban farms represent highly heterogeneous environments, complicating on-farm food safety efforts* by **Daniel Weller**, **Tanzy Love**, **Claire Murphy**, **Patrick Baur**, **Angela Ferelli**, and

Laura Strawn, who find a myriad of issues that may exacerbate microbial and chemical preharvest food-safety risks. Finally, in their literature review, *Women as catalysts of rural transformation A systematic review of barriers, opportunities, and policies in the Global South*, **Rika Reviza Rachmawati**, **Mia Siscawati**, **Francisia Saveria Sika Ery Seda**, and **Hariati Sinaga** find that, despite constituting the majority of the agricultural workforce in many regions, women are not treated equitably, and this is holding back the development of resilient food systems in lesser development countries.

We conclude this issue with five reviews: four books and one film. **Wendy Nevett Bazil** reviews *Food Policy Councils: Building Civic Engagement and Community Well-Being*, by Nessa J. Richman. **Sofia Francisco** reviews *Truffles and Trash: Recirculating Food in a Social Welfare State*, by Kelly Alexander. **Elisabeth Ramsey** reviews *Africulture: How the Principles, Practices, Plants, and People of African Descent have Shaped American Agriculture*, by Michael Carter Jr. **Molly DelCarmen Anderson** reviews the film *Serán las dueñas de la tierra* (*Stewards of the Land*) which is about the future of Puerto Rican agriculture. And finally, **Stacey Stearns** reviews *The Almond Paradox: Cracking Open the Politics of What Plants Need*, by Emily Reisman.

In wrapping up this issue—which marks a full 15 years of publishing JAFSCD—I circle back to our theme of *sustainable diets* and invite readers, scholars, professionals, and practitioners to consider teaming up to produce two-page, peer-reviewed briefs on this emerging subfield of food systems. The topic of sustainable diets covers a wide swath of the consumption and environmental domains, and our aim is to build practical snapshots of the state of the art in sustainable diets—from food as medicine to underutilized, traditional, Indigenous, and biodiverse foods. Learn more about the Sustainable Diet Briefs series at the JAFSCD Sustainable Diets Editorial Circle page.[2]

Yours for increasing the sustainability of our consumption,



Duncan Hilchey
Publisher and editor-in-chief

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THE ECONOMIC PAMPHLETEER
JOHN IKERD

Breaking the cycles of co-optation

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The industrialization of agriculture has faced resistance in the U.S. since at least the early 1900s. The rise of organic agriculture in the 1940s, of sustainable agriculture in the 1990s, local foods in the early 2000s, and regenerative agriculture in the 2020s were all responses to growing concerns about the environmental, socioeconomic, and public-health consequences of industrial agriculture. One by one, each movement has been co-opted by industrial agriculture. With growing concerns about increasingly volatile weather, market prices, and input costs, "resilient agriculture" could be the next challenge to industrial agriculture.

The co-optation is likely to continue, unless there is a fundamental change in strategies for challenging industrial agriculture and whatever its descendants may be in the era of high-tech farming. First, mainstream producers, processors, or retailers have waited for farmers to develop niche markets for organic, sustainable, local, regenerative, or other anti-industrial products. When a niche becomes large enough to become a significant source of corporate profit, they find ways to redefine the concept to accommodate their industrial production systems. They then make the redefined product more conveniently available at prices that are unprofitable for authentic organic,

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Why an Economic Pamphleteer? In his historic pamphlet *Common Sense*, written in 1775–1776, Thomas Paine wrote of the necessity of people to form governments to moderate their individual self-interest. In our government today, the pursuit of economic self-interest reigns supreme. Rural America has been recolonized, economically, by corporate industrial agriculture. I hope my "pamphlets" will help awaken Americans to a new revolution—to create a sustainable agri-food economy, revitalize rural communities, and reclaim our democracy. The collected Economic Pamphleteer columns (2010–2017) are available at https://bit.ly/ikerd-collection

sustainable, local, or regenerative producers and capture the market.

Organic food production is a prime example of this strategy (Ikerd, 2018). Organic farmers developed local and regional markets for organically produced foods, which were generally sold at farmers markets, local food co-ops, and health food stores. However, there was no single definition of organic farming. As the organic market grew, mainstream food retailers insisted that uniform national standards for organic production must replace the diverse state and regional standards for organics to continue growing. Organic farmers who wanted access to national markets worked with mainstream agri-food corporations and the U.S. Department of Agriculture (USDA) to establish the National Organic Program (NOP). The new federal regulations defined organic production in terms of allowable and excluded inputs, ingredients, and production practices. Any product labeled as *organic* in the U.S. must be grown, handled, and processed in compliance with the NOP standards.

Industrial agriculture remains firmly in control of organic farming and food production in the U.S.

As mainstream corporations gained larger shares of the organic market, they gained enough political influence with the NOP to resist, revise, and reinterpret the organic standards to accommodate their industrial production systems. For example, USDA-certified organic vegetables and berries can now be produced without soil, and organic milk and yogurt can come from animals that spend most of their lives confined in large factory-like facilities. These standards are far different from the organic practices of the farmers who developed the organic market.

The Real Organic Project (n.d.) developed an optional add-on certification that prohibits hydroponic plant production and concentrated animal feeding operations. However, industrial agriculture remains firmly in control of organic farming and food production in the U.S.

Sustainable agriculture gained national attention as a compromise between advocates of organic and industrial agriculture policies. The 1980 USDA *Report and recommendations on organic farming,* commissioned by then-Secretary of Agriculture Bob Bergland and carried by a multidisciplinary team of scientists, concluded that USDA programs supporting organic farming were woefully inadequate, but perhaps more importantly, that industrial agriculture was not ecologically or socially sustainable (USDA Study Team on Organic Farming, 1980). The incoming administration at USDA ridiculed the report and had the remaining copies destroyed, but organic advocates continued to pressure the government for support.

Industrial agriculture advocates saw sustainability as an opportunity to defuse the growing political pressure of organic farmers. In 1987, the United Nations Brundtland Commission concluded: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 15). Industrial advocates interpreted sustainable agriculture as the ability to continue increasing production while reemphasizing soil and water conservation practices, which the USDA had subsidized since the 1930s.

Organic advocates, on the other hand, understood sustainable agriculture as a *permanent* agriculture, capable of meeting basic human needs indefinitely. Organic farming pioneer Lady Eve Balfour wrote,

> The criteria for a sustainable agriculture can be summed up in one word—permanence, which means adopting techniques that maintain soil fertility indefinitely; that utilise, as far as possible, only renewable resources; that do not grossly pollute the environment; and that foster life energy (or if preferred biological activity) within the soil and throughout the cycles of all the involved food-chains. (p. 5)

Industrial organizations co-opted sustainability much the same as they had organics, but without going through the standardization process. The

corporate world, agricultural and otherwise, narrowed the definition of sustainability to environmental protection and resource conservation rather than permanence or the ability to continue producing indefinitely. Corporate sustainability programs generally include commitments to reduce emissions of toxic wastes, substitute renewable for nonrenewable resources, and increase the efficiency of resource use. And, they only implement programs that do not compromise their profitability. The corporate takeover of sustainable agriculture met with little resistance as the concept was never fully embraced by organic or other non-industrial farmers, perhaps because it seemed too abstract.

In the late 1990s and early 2000s, consumers concerned about the industrial agrifood system turned to their local farmers to ensure the integrity of their food (Ikerd, 2020). They trusted local farmers to produce good food by organic, organic-like, or other sustainable means. However, as the popularity of local foods grew, mainstream marketers once again saw a potentially profitable niche market. The co-optation started with some innovative local retailers and national chains, such as Whole Foods. However, mainstream supermarkets soon started featuring a variety of "locally grown" food products (Ellis, 2025). Today, *local* in supermarkets may mean within 100 miles, 500 miles, in the same state, or the same general region of the country as the store. There is hardly an opportunity for consumers to assess the integrity of their farmers or food in such instances. Again, an anti-industrial market niche has been reinterpreted and co-opted.

The next challenge to industrial agriculture was regenerative agriculture. Advocates of regenerative agriculture claim that sustainable agriculture is not enough, implicitly suggesting that the current food system is sustainable, although it isn't (Rodale Institute, 2019). The Brundtland Commission concluded, "Sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life" (United Nations, 1987, p. 15). Restoration and regeneration are requisites or necessary conditions for sustainability, not beyond or better than sustainability.

Regardless, industrial agriculture is currently co-opting regenerative agriculture In 2015, Regenerative International defined regenerative agriculture as farming systems that improve the health and productivity of the natural environment, soils, plants, animals, humans, and communities (Leu, 2023). Agribusiness corporations, in collaboration with the USDA and nongovernmental organizations (NGOs), have taken the lead in redefining regenerative agriculture as a set of farming practices to rebuild and sustain soil health (Bless, 2025). Advocates of the soil-focused definition of regenerative agriculture contend that only large farming operations can change agriculture fast enough to meet the challenges of climate change. However, the focus on soil health marginalizes or ignores the other ecological and social foundations of regenerative farming, much like the emphasis on inputs distracts from other essentials of organic farming.

Restoration and regeneration are requisites or necessary conditions for sustainability, not beyond or better than sustainability.

The USDA has launched a new US$700 million regenerative pilot program focused on soil health, water quality, and long-term productivity (USDA, 2025). An add-on *regenerative organic* certification program has been developed that adds criteria for soil health, animal welfare, and social fairness to USDA organic standards (Rodale Institute, n.d.). It remains to be seen whether the add-on certification will gain traction beyond row crop production, where soil health is an issue but animal welfare and social fairness concerns are absent or minimal. Retailers, thus far, are treating regenerative foods much the same way as organic foods before certification; a 2025 Congressional report notes,

> Despite a lack of consensus about how to define *regenerative* and the absence of federal enforceable certification standards, several

> food companies and retailers have adopted policies to label and market some food products as regenerative or as regenerative organic based on criteria developed under private sector (nongovernmental) initiatives. (Stubbs & Johnson, 2025, Summary)

The next logical challenge to agricultural industrialization would be *resilient* agriculture (Ostane-Baucom, 2025). Resilience farming refers to the ability to withstand, recover from, and adapt to disruptions or shocks—such as adverse weather events, volatile prices and input costs, and disease and pest outbreaks. Resilient farms rely on biodiversity, soil health, and adaptive management strategies to mitigate threats to their survival (Lengnick, 2021). Industrial agriculture, on the other hand, depends on government programs, such as subsidized crop revenue insurance and disaster payments. With the more volatile weather patterns associated with climate change, supply-chain vulnerabilities revealed by COVID-19, and continued disruptions in global trade, resilient agriculture seems a logical alternative to the taxpayer-supported industrial agrifood system.

With continued disruptions, resilient agriculture seems a logical alternative to the taxpayer-supported industrial agrifood system.

If so, what could be done to reduce the risks of co-optation for resilient agriculture? First, avoid uniform national standards for resilience, especially standards based on specific farming methods or practices. For example, while diversification is essential for resilience, the high-tech (biotech, infotech) descendants of industrial agriculture can manage any system that can be expressed as an algorithm, no matter how complex. The tendency to quantify resilience in terms of variability should also be avoided. Resilience requires the ability to rebound, adapt, and evolve as well as increase stability. Neither can resilience be quantified economically, since money cannot restore the life of an ecosystem, family farm, or community that fails to survive adversity. Advocates of resilient agriculture must also reject the claim that if large farming operations do not support resilient agriculture, change will not come fast enough (USDA Farm Income Team, 2026). The risk of large farms changing too little, or not at all, is greater than the risk of all farms changing too slowly, or too late.

Resilience cannot be quantified economically, since money cannot restore the life of an ecosystem, family farm, or community that fails to survive adversity.

A more logical way to break the cycle of co-optation would be to change the basic approach to transforming the agri-food system. Past approaches have treated changes in farming practices as proxies for changes in the purpose of farming. For example, every significant challenge to industrial agriculture has been rooted in the principles of permanence. The original definitions of organic, sustainable, regenerative, and resilient included the ecological, social, and economic dimensions essential for a permanent agriculture. Industrial agriculture co-opted these initiatives by simplifying and redefining the concept in terms of production practices. But industrial producers cannot meet the needs of all in society indefinitely or permanently without abandoning the industrial system of production.

Two additional keys to avoiding co-optation are prioritizing individuality over uniformity and networking or scaling *out* over scaling *up*. Lady Eve Balfour wrote: "Contrary to the views held by some, I am sure that the techniques of organic farming cannot be imprisoned in a rigid set of rules. They depend essentially on the outlook of the farmer" (1977, p. 5). The same is true for other non-industrial approaches to farming. The techniques of permanent farming depend on the individual farmer's perspectives. Rather than uniform national standards, permanent agri-food systems also must be

local and regional to accommodate their unique ecological and cultural niches. Local food systems must network with other like-minded communities and scale out rather than scale up to perform functions and provide products that are not available locally. People in a permanent society must work and live in harmony with nature, including human nature.

Permanence will require a sense of connectedness, confidence, and trust between farmers and consumers to offset the cost and convenience advantages of industrial production and distribution. Local and regional food systems may choose to label their products organic, sustainable, local, regenerative, resilient, or any term that clearly differentiates them from the industrial food system. The more definitions and labels, the less risk of co-optation. However, permanence cannot be imprisoned by any rigid set of rules; it depends on the integrity of the farmer.

Permanence will require a sense of connectedness, confidence, and trust between farmers and consumers to offset the cost and convenience advantages of industrial production and distribution.

This approach to food production is consistent with agroecology, permaculture, food sovereignty, bioregionalism, and other non-industrial agri-food systems. There is no lack of information on farming systems that could accommodate the purpose of permanence. The success of these alternative approaches depends on people living and working together to restore, respect, protect, and preserve their quality of life and their unique niches in nature. They can minimize the risks and realize the benefits of regionalism, nationalism, and globalism by forming and sustaining positive relationships with those in other like-minded communities. Such relationships will be unique to specific people and places and cannot be co-opted.

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VALUE CHAIN COORDINATION COLUMN

Bridging margin and mission

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My local grocery cooperative has an informal motto of "No Margin, No Mission." This pithy expression, likely familiar to many JAFSCD readers and community development practitioners, is a catchy shorthand for the financial reality that business viability is a necessary prerequisite for fulfilling an organization's social and/or environmental mission (Diamond & Barham, 2011). Working in local and regional food systems, I find this simple mantra helpfully summarizes the dual-bottom-line challenge of supporting thriving, resilient regional food economies that can simultaneously support farmers, their environment, and the communities they feed.

Value chains are food supply chains that link agricultural producers with markets, adding economic value throughout. As I have written in this column previously (Hall et al., 2026), value chains may also prioritize the core mission of farm viability, ecological sustainability, and access to healthy foods or other community benefits. Value chains are facilitated by relational infrastructure, provided by networks of coordinators that hold strategic partnerships and actively foster win-win relationships across participants within the supply chain. Value chains struggle to perform, however, unless the businesses along the chain are fiscally functional and the relational infrastructure connecting them is adequately resourced. The relationship runs both ways: coordination helps enable fair returns, and those returns in turn sustain the businesses and relationships that create further value.

Value chain coordination (VCC), the interstitial capacity supporting functional chains, is at the center of two distinct financing questions critical to the success of local and regional food systems. The first concerns how the coordinator, whether an entity, network, or an individual, is compensated for their relational labor of organizing and maintaining value chains that meet community priorities. I addressed this question briefly in the previous column in which I argued that evaluation of coordination activities and outcomes should be built into program design, in part to demonstrate

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to funders the value of the "soft infrastructure" in system performance.

This column takes up the second question, which concerns how value chains achieve financial viability in practice. This asks both how particular initiatives—like a local farm-to-hospital program—are coordinated and funded and, more fundamentally, how value chains broadly become and remain financially solvent. In my experience, this varies substantially and is a frequent pain point for coordinators trying to activate new markets and maintain durable supply chain relationships. Each market segment carries its own conditions and procedures for ensuring sustainable revenue (e.g., Medicaid 1115 waivers, which let some states pilot reimbursing food costs as medicine)—a complexity we hope to unpack further through the JAFSCD VCC Brief Series.[1] Whatever the mechanism, the math is the same: no margin, no mission. And closing that gap is where coordinators spend much of their labor.

Value chain coordinators are often essential architects scaffolding regional economic infrastructure.

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Value chain coordinators are often essential architects scaffolding regional economic infrastructure. As systems matchmakers, they resolve the tension between the margin constraint of financial viability and the mission horizon of community development by addressing supply chain disconnects and innovating place-based opportunities (Rocker, 2019).

Coordinators help manage strategic price discovery to facilitate transparent pricing in transactional markets and secure fair cost-of-production pricing for mid-tier food enterprises. By bringing institutional or wholesale buyers to the table with regional producers, coordinators can broker fair prices, higher volumes, or forward contracts (often growing out of stand-alone deals) that provide stability for buyers and predictable income for producers, aligning volume commitments to support farm margins while securing bulk discounts. For farm households, this stability can mean the difference between operational success and failure.

Even when local supply and demand are present and evenly matched, regional food markets face challenges in the aggregation and logistics of transporting small batches independently. Coordinators draw on supply-shed knowledge and map regional distribution networks to align empty truck space, optimize backhaul routes, and establish decentralized drop-sites, both reducing cost and allowing small, dispersed farms to enter markets that they could not reach alone.

Coordinators connect producers with technical assistance to develop farm-specific action plans and lower the administrative hurdle of audits and recordkeeping.

Coordinators also broker market access itself, translating compliance and food safety requirements into terms small and mid-sized producers can act on, supporting their fiscal viability. For example, anchor institutions like school districts and universities increasingly require Good Agricultural Practices (GAP) produce safety certification. Coordinators connect producers with technical assistance to develop farm-specific action plans and lower the administrative hurdle of audits and recordkeeping, allowing regional farms to participate in and benefit from the large-buying power of institutional markets.

[1] JAFSCD has launched a series of peer-reviewed, two-page briefs that distill well-established policies, programs, and practices in local and regional food systems into concise, high-impact publications designed to inform and inspire practitioners, policymakers, researchers, and advocates working across the food system. Learn more at https://www.foodsystemsjournal.org/index.php/fsj/VCCEC and see the series at https://www.foodsystemsjournal.org/index.php/fsj/jafscdbriefs

* * *

Value chain coordinators also regularly serve as "resource prospectors," connecting food system stakeholders to grants, loans, and technical services (Rocker, 2019). As regional food systems mature, this role is specializing, in some cases, into something more explicitly finance-oriented: capital coordination. Value chains are routinely bottlenecked by lack of access to appropriately structured capital, particularly for enterprises in the "missing middle," the supply chain intermediaries between farms and buyers, which are often too large for microloans or direct-market revenue and too small or thinly margined for conventional commercial financing.

Whereas traditional lending weighs risk and return alone, impact-oriented investing accounts for a third dimension of social or environmental outcome (i.e., the community priorities that drive value chains) (Federal Reserve Bank of St. Louis & Board of Governors of the Federal Reserve System, 2017). Capital coordinators help pull together public, private, and philanthropic capital around a shared vision for value chain development that holds this third dimension of impact alongside return. They draw on coordination skills in education and relationship-building to match systems-minded impact investors with small and mid-sized agri-food entrepreneurs across regional supply chains, translating between different frameworks and building confidence and trust. As place-based systems thinkers, knowledgeable about local supply and demand needs and opportunities, value chain capital coordinators link regional enterprises with financial markets otherwise closed to them, assembling the patient, blended capital stacks that missing-middle food businesses need to grow.

Value chain capital coordinators link regional enterprises with financial markets otherwise closed to them.

Networks of capital coordinators, composed of investors and funders in collaboration with food system stakeholders and squarely focused on transforming regional food and agricultural systems, are emerging across the country. In the American Midwest, the TransCap initiative has identified "capital orchestrators" as a critical gap in the soft infrastructure needed to accelerate transitions to regenerative agriculture. TransCap is now actively convening a collaborative design effort to strategically deploy capital across the region (Gazibara, 2025).

In the Mid-Atlantic, a community development financial institution (CDFI) has partnered with a local food hub and environmental non-profits to launch a "Coordinated Capital Coalition" to pilot a regional strategy for systemic investing (Locus, 2026). Intentionally collaborating across food and financial markets, their approach aims to orchestrate integrated interventions that unlock investment opportunities and market-driven solutions for farms and food businesses. In both cases, coordination makes capital work for both margin and mission alike. The U.S. Department of Agriculture's Agricultural Marketing Service (USDA AMS) is supporting this work to learn more about how such capital coordination can unlock investment and strengthen regional food value chains.

The entrepreneurial farms and food businesses I have worked with know that the mission is not superfluous. It provides the competitive advantage that distinguishes a value chain in a crowded food marketplace. But a mission without a viable value chain to carry it will not survive. As the JAFSCD VCC Briefs Series continues, we're eager to hear how your initiatives are financed: what mix of grants, patient capital, and market revenue keeps your value chain solvent, and where are the remaining gaps?

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VIEWPOINT

Emancipatory scaling: Strengthening locally led AR4D innovation processes

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Introduction

Agricultural research for development (AR4D) increasingly seeks to scale innovations that can transform food and agricultural systems. Yet scaling is still often framed as a technical exercise of replicating solutions, expanding reach, and delivering measurable outputs. This viewpoint argues that such approaches underestimate the political, relational, and context-dependent nature of systems

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change. They risk privileging funder and institutional priorities, overlooking local realities, and positioning communities primarily as adopters rather than as actors with authority to shape innovation pathways. In response, we introduce the concept of *emancipatory scaling*. Drawing on emancipatory research traditions, responsible innovation, and responsible scaling, the concept shifts attention from scaling solutions to transforming the conditions under which scaling takes place. Emancipatory scaling is characterized by meaningful participation as co-control, reciprocal accountability, community agency over research agendas and outcomes, recognition of diverse knowledge systems, and sensitivity to socio-ecological interdependencies.

Keywords
emancipatory scaling, locally led, AR4D, systems change

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Rethinking Scaling

Agricultural research for development (AR4D) is increasingly tasked with generating multiple 'game-changing' and 'scalable' innovations in order to transform agricultural systems and ensure that they are climate-resilient, productive, sustainable, and equitable (Hellin et al. 2024).

Yet scaling, often understood in narrow terms of 'scaling out,'[1] is treated as a technical challenge and identified as an end goal, rather than as a process of systems change with often unpredictable and medium- to long-term changes (Woltering et al., 2024). Scaling thus tends to become a 'projectivized' question of identifying what technology or innovation works in one context and replicating it elsewhere, thereby 'engineering' change through delivery pipelines toward aspired goals (Woltering et al., 2019). Such forms of scaling position communities primarily as beneficiaries or adopters rather than as groups of actors with legitimate authority to co-define problems, set priorities, and judge outcomes (McGuire et al., 2025).

Priorities are frequently set through funder and governmental agendas, often with insufficient engagement of socially disenfranchised and local communities (McGuire et al., 2025). Interventions can thus slide into a 'copy-paste' mentality that does not recognize and undervalues local context and the lived realities that shape feasibility, desirability, and risk perceptions (Bogweh Nchanji et al., 2025). Many researchers working on scaling in AR4D shy away from taking responsibility for their roles in the process, emphasizing path

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[1] It is important to distinguish three scaling pathways: scaling out (reaching more people through replication and diffusion), scaling up (changing institutional, policy and legal conditions), and scaling deep (transforming relationships, cultural values and beliefs) (Moore et al., 2015).

dependency and governance constraints that lock scaling trajectories into default patterns (Kihoro et al., 2025).

Critical development research has further argued that scaling is an inherently normative and political process, shaped by power inequalities between actors and by the interests embedded in funding models, institutional incentives, and dominant knowledge systems (Altshul, 2025; Avelino, 2021) that are often still reflected in (post)colonial relationships (Icaza & Vázquez, 2016; Mpofu & Ndlovu-Gatsheni, 2019; Tsing, 2012). As Woltering et al. (2019) write, the interactions embedded in scaling processes are determined less by "linear cause-effects between tangibles in technical dimensions … [and] by more concrete relational factors such as motivation, norms, and (power) relations" (p. 4). When scaling is framed primarily as an implementation problem, the question of whose voices are 'represented' and priorities are being pursued—and on what terms—become secondary or even silenced (Hellin et al., 2024; Kapoor, 2004; Spivak, 1988).

The practice of scaling has thus focused too much on scaling 'ships'–the solutions–and not enough on the diverse 'waters' they operate in–the communities, ecosystems, cultures, and institutions that allow change to endure (Kak, 2026; Stirling 2009).

Responding to these extant critiques, we[2] argue that AR4D needs to move toward *emancipatory scaling*: understanding locally led innovation processes, starting innovation with the voice and realities of people and landscapes, and enabling actors to drive the change they want (Habermann et al., 2023; Spivak, 1988). This implies a shift in who is recognized as having the right over their (own) resources and as holding epistemic authority (whose knowledge and lives count) and in how legitimacy is earned, through accountability to those most affected, not only to funders or peer review (Altshul, 2025; Ludwig et al., 2021).

Defining Emancipatory Scaling

Drawing on Oliver's (1992) foundational criteria for emancipatory research—reciprocity, gain and empowerment—and Barnes's (2004) elaboration of the emancipatory paradigm, emancipatory scaling can be characterized by meaningful participation in the sense of co-production rather than consultation; accountability of researchers to reciprocal benefit; agency of communities over the research agenda and its uses; and connecting research with the everyday realities and knowledge of communities, rather than treating communities as passive recipients or sources of data to ensure legitimacy to funders.

Critically, this new conceptualization is not meant to displace the role of responsible innovation (RI) and responsible scaling (RS) that similarly support *opening up* how research and innovation is pursued, anticipating unintended impacts, reflecting on assumptions and motivations, engaging diverse stakeholders in broader deliberation, and using these processes to influence the direction of innovation itself (Ewell et al., 2026; Kihoro et al., 2025; Stilgoe et al., 2013; Wigboldus and Brouwers, 2016).

Yet emancipatory scaling can be set apart in three ways. First, the deliberative governance processes that RI prescribes remain largely upstream, with researchers and policymakers tasked with applying RI principles during innovation design and testing, yet neglecting downstream conditions and impacts (Ewell et al., 2026; Leeuwis et al., 2026; Stilgoe et al., 2013). Emancipatory scaling positions innovation users and communities not merely as stakeholders to be engaged but as innovators and co-definers of what counts as a good innovation outcome in the first place. It also recognizes nonhuman actors as integral to innovation processes, foregrounding relational interdependencies and advocating for scaling pathways that are interdependent with ecological agencies and more-than-human ethics of care (Seymour & Connelly, 2022; Tsing, 2012). Second, rather than asking how to *innovate* responsibly, emancipatory scaling asks *for*

[2] We are a group of nine PhD students who came together as part of a tailor-made course on "systems thinking–led science and practice for responsible scaling," and also researchers of CGIAR—the global partnership for a food secure future—with hopes of planting constructively disruptive seeds of change in AR4D research practice.

whom and *whether* to scale at all—interrogating the structural conditions, including capitalistic and extractive development models and representational inequities, that shape which innovations get resourced and whose knowledge systems get recognized (Asher & Wainwright, 2019; Stirling, 2009). Third, the locus of agency shifts. In RS, it is often still researchers, funders, and business partners who manage the scaling processes, though with increasing stakeholder input. In emancipatory scaling, communities and local actors hold meaningful decision-making authority over (a) which innovations are pursued, (b) how those innovations are configured and governed, (c) how benefits, burdens, and rights are handled over time, and (d) recognize their internal capacity to innovate (see also Baker et al., 2009). As such, emancipatory scaling allows practitioners and researchers working in AR4D to start to revise existing relationships and recognize 'new' relationships that can support the livelihoods of those to which they matter the most.

Moving from Theory to Practice

Overall, emancipatory scaling rejects the assumption that scaling is inherently good, neutral, or purely technical. The path forward therefore is not simply to pay lip service to concepts such as 'co-production' and its cognates of being 'participatory,' but to adopt locally relevant metrics alongside conventional indicators, strengthen innovation in local change processes, institutionalize justice-oriented questioning, and build transdisciplinary governance arrangements that can meaningfully redirect trajectories when scaling serves narrow interests, sidelines voices, or erodes rights (see also Ewell et al., 2026; Petesch et al., 2024).

Quantitative, output-oriented metrics of success of scaling, such as the number of technologies produced or consumers reached, risk conflating reach and 'quick wins' with impact which actually is determined by underlying pathways of trust and relationship building, and obscuring the complex, multi-actor processes required for adoption and scaling (Independent Advisory and Evaluation Service [IAES], 2026; Leeuwis & Aarts, 2021; Martinez-Baron et al., 2026). While attractive to stakeholders and funders, conventional indicators raise concerns about attribution and tend to shift attention away from community goals. Unfortunately, in many cases this exacerbates power relations, and may result in 'maladaptation,' whereby agricultural innovations benefit the better-off, often male, farmers and lead to growing inequalities (Schipper, 2020; Shawoo et al., 2025). Emancipatory scaling counters this tendency by introducing *emic* metrics: indicators defined from within local spaces that capture what people consider meaningful change (e.g., autonomy in decisions, dignity, safety, reciprocity, trust, and control over resources) (Chang, 2009). For example, Zaremba et al. (2024), examined local, emic definitions of 'empowerment' and note the critical role of perceptions by communities that can hinder the acceptance of empowered women.

Positive deviance offers one route for grounding scaling in endogenous change. Instead of starting from externally designed 'best practices,' positive deviance begins by identifying individuals or groups who are achieving positive outcomes or are 'pioneers' in adopting new practices, then amplifying what they do through peer learning, local organizations, social movements and institutions, and further culturally resonant mechanisms of diffusion (Albanna et al., 2022; Habermann et al., 2025). It shifts the locus of knowledge and agency from external experts to communities themselves, recognizing that solutions and capacities for innovation already exist among individuals despite shared constraints, and enabling others to learn from these locally embedded practices (Bader & Reinbott, 2023). For instance, a study on adaptation to climate change in the Ethiopian highlands found that mutual learning from pioneer farmers during field days "have proven to be effective platforms for … upscaling of farmer-led innovations" (Habermann et al., 2025, p. 170).

Finally, emancipatory scaling requires power-shifting design choices. It challenges entrenched power structures that limit equitable collaboration, prompting ongoing (re-)consideration of who makes decisions and who benefits as contexts change. Emancipatory scaling thus also requires new types of transdisciplinary partnerships. While the "*epistemic promise* of transdisciplinarity is to generate more robust research by bringing the expertise of diverse actors together" (Ludwig & El-Hani,

2025, p. 21), it is critical for more interventions to take the needs, perspectives, and values of heterogenous actors into account and thereby pursue "reciprocAbility" (Kehrer et al., 2020, p. 49), whereby partners can influence (a) the definition and framing of the problem, (b) goals, (c) indicators, (d) means, (e) metrics, and (f) processes pursued.

These solutions will, however, require a substantial shift in how AR4D conceptualizes 'effectiveness' and interacts with diverse scaling partners who, ultimately, are often the ones best positioned and responsible in driving the scaling process. Emancipatory approaches must take politics seriously, not only to understand, but most importantly to be able to challenge current dominant orders (Mouffe, 2005). Innovation processes are inherently driven by interests and worldviews, and 'emancipatory processes' can be captured (un)intentionally by elites, whether local, institutional, or social-political (Taiwo et al., 2022).

Furthermore, the need for emancipatory scaling comes at a taxing time for agricultural researchers. Intense competition for ever-reducing research funds, together with the commensurate pressure to demonstrate impact or "implode" (Reed & Fazey, 2021, p. 2). New ways of doing research are needed to tackle the deep interconnected nature of 21st-century challenges, like climate change, nutrition, and entrenched social and economic inequalities. Yet little is known about how more or less healthy 'impact cultures' might be characterized, or the factors that shape these cultures. Emancipatory scaling provides one critical as well as a constructive way to overcome the gap between grassroots transformations and the structural changes needed for impact at scale.

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VIEWPOINT

Sub-Saharan Africa is experiencing a food-related health risk problem in informal food environments: An urgent need for science and policy actions

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Introduction

Sub-Saharan Africa's (SSA) food systems have been transformed by science-driven gains in productivity and market access, yet a health crisis is intensifying within its vast informal food environments. Agricultural research and technology investments have strengthened smallholder systems (Shilomboleni & De Plaen, 2019) and expanded food availability (Clark & Hobbs, 2023), while rising socioeconomic conditions escalate nutritional demands (Blekking et al., 2022; Djurfeldt, 2015) and propel calls for dietary diversity (Paulo et al., 2024; Usman & Haile, 2022). However, these advances are harshly undermined by the burden of foodborne diseases. An

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estimated 91 million people in Africa fall ill annually from food-related illnesses, generating over US$15 billion in medical costs and 137,000 deaths (Nigussie et al., 2025; World Health Organization [WHO] Africa, 2019), with downstream economic losses in tourism (Chen et al., 2021). Agrochemical residues, poor hygiene, and weak legislative enforcement in Africa's largely informal food sectors drive this burden.

Here, we synthesize health threats in informal food environments and call for an urgent agenda to protect public health across SSA. This viewpoint provides a snapshot of health-risk exposures across the three dominant value chains: fruits and vegetables, livestock, and aquatic foods. It emphasizes that while food availability, affordability and accessibility reduce food insecurity, they mask uncontrolled hazards. Addressing this demands research to characterize risks, quantify health and economic burdens, and develop context-specific interventions. Integrated science-policy action must follow to safeguard populations relying on these environments.

Keywords
health risk, food safety, policy, informal food environment, sub-Saharan Africa

Food Chain Hazard Profile in SSA

Informal food chains in SSA supply most urban households, but the associated production and vending practices introduce biological and chemical hazards, undermining nutrition, causing preventa-

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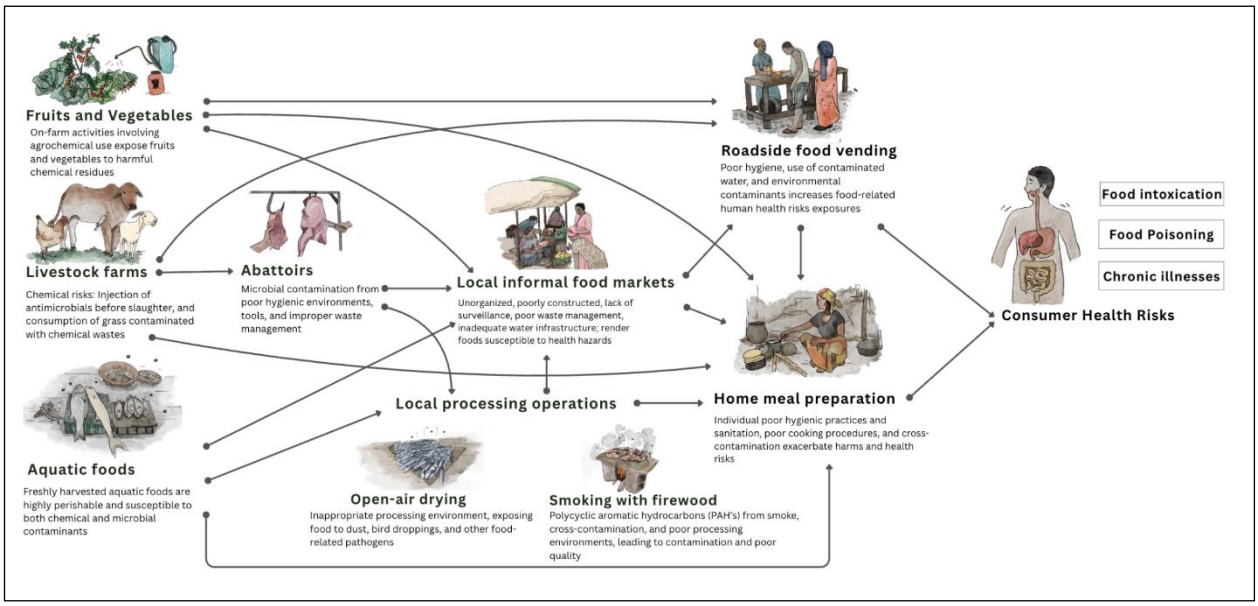
Figure 1. Graphical Representation of the Health-Risk Exposures across Three Key Food System in Informal Food Environments



ble illness, and exposing structural failures that require integrated policy action (see Figure 1).

Specifically, in fruits and vegetables, pesticide overuse leaves residues. In Uganda, 95.6% of samples contained organophosphates and carbamates (Ssemugabo et al., 2022); in central Ethiopia, 45–60% exceeded EU limits (Dinede et al., 2023). In the post-harvest stage, roadside display on bare ground and juice processing in unsanitary environments (where 82.4% of Ethiopian vendors lacked gloves and 58.8% of sites were unsanitary), fecal pathogens such as *Salmonella*, *Staphylococcus aureus*, and *E. coli* were introduced (Ebrahim & Wondimagegn, 2025). Parasites like *Giardia lamblia* contaminate 33.3% of market vegetables. Consequently, these hazards suppress the average consumption of fresh vegetables to 284 grams/day/person, well below the WHO 400 g target, underlining the failure of regulatory oversight (Okekunle et al., 2024).

Similarly, livestock value chains harbor zoonotic threats: gastrointestinal nematodes infect 92.9% of Ethiopian animals (Kimeli et al., 2025), and anthrax and Q fever attack rates of 54.4 per 1,000 and 345.4 per 1,000, with a 345.4 per 1,000 fatality rate, signal acute spillover (Ateudjieu et al., 2023). Over 70% of medically important antimicrobials used in husbandry drives up to 62.7% resistance of *E. coli* in Ugandan poultry (Elbehiry & Marzouk, 2025). Moreover, informal slaughter amplifies contamination: only 3 of 36 Nigerian states have standard abattoirs; handlers work without training or protective equipment; and unsanitary surfaces elevate *Salmonella* and *E. coli* (Christiana Cudjoe et al., 2022; Ovuru et al., 2024). Additionally, raw milk consumption by 34.46% of Rwandan farmers directly transmits Brucella, while undercooked meat transmits *Taenia solium*, perpetuating disease cycles amid weak enforcement (Christiana Cudjoe et al., 2022; Munyaneza et al., 2025).

Furthermore, aquatic foods are prone to spoilage, adulteration, and chemical contamination. Formalin was detected in all Ghanaian fish species sampled, ranging from 0.174 to 3.710 microgram (μg)/g (Asare-Donkor et al., 2018). Traditional smoking generates carcinogenic PAHs; Senegalese samples reach benzo(a)pyrene 33 μg/kg and total PAHs 1082.3 μg/kg (while the EU limits are 2 and 12 μg/kg) (Diop et al., 2023). Lake Victoria sardines have median cadmium levels of 0.081 mg/kg and lead levels of 0.012 mg/kg, yet 96% of Tanzanians remain unaware of contamination (Venant et al., 2025). Organochlorine metabolites account for

55–60% of pesticide loads in Ghana, elevating cancer risk (Adokiya et al., 2025). Consequently, the absence of cold chains, open-air drying, and weak regulations expose fish products to dust, droppings, and mold, while chemical additives compound the threat.

Factors Associated with Health Risk Exposures in SSA

Informal food environments in SSA supply most of people's daily sustenance, yet these environments operate with regulatory neglect, infrastructural collapse, and socioeconomic entrapment that systematically generate health risks. This section dissects these interconnected drivers, revealing an imperative for integrated, evidence-based policy intervention.

Poor Food Safety Procedures, Regulations, and Enforcement

Regulatory frameworks remain profoundly fragmented. For example, Namibia enforces Hazard Analysis and Critical Control Points (HACCP) systems exclusively in formal fish processing, leaving compliance in informal operations to vendor discretion (Haimbala, 2021). Heavy-metal testing covers commercial seafood but bypasses small-scale and informal harvests, despite documented contamination risks (Erasmus et al., 2018). In other contexts, weak agrochemical oversight introduces chemical residues directly into food chains, precipitating health crises across the region (Malhat et al., 2025). Critically, inspection regimes across the region target export and import commodities while neglecting the domestic informal markets that feed the vast majority of the population. This regulatory asymmetry creates a de facto dual system in which local consumers bear disproportionate exposure to unmonitored hazards.

Inadequate Infrastructure for the Local Food Environment

Infrastructure gaps magnify these vulnerabilities. For example, perishable fruit and vegetable value chains lose up to 72% of tomato harvests due to the absence of cold storage, a spoilage rate that simultaneously destroys nutrition and fosters mycotoxin-producing fungi (*Aspergillus*, *Penicillium*, and *Fusarium*) in the retained fraction (Christiana Cudjoe et al., 2022; Nigussie et al., 2025; Owino et al., 2025;). Aquatic foods suffer parallel post-harvest decay and become vectors for *Vibrio cholerae* and heavy metals when processed with contaminated water or ice. The livestock sector, which channels an estimated 70–80% of meat through informal markets, epitomizes systemic failure: unregulated slaughtering occurs without reliable veterinary inspection, water, or waste disposal, often under trees or in dilapidated structures where floors go uncleaned due to water scarcity (Abdullahi et al., 2025; Hannah et al., 2025; Hossain et al., 2025). These commodity-specific risks converge in marketplaces that uniformly lack potable water, sanitation, and waste management. This foundational deficit, affecting over 80% of the population, transforms waterborne pathogens into foodborne threats and drains an estimated 5% of regional GDP annually (Chirwa & Nyong, 2025; Dos Santos et al., 2017; Sheehama & Singh, 2025).

Socioeconomic Constraints on Food Safety

Socioeconomic realities lock these hazards in place. In particular, most informal food actors have limited formal education and minimal access to food safety training, thereby entrenching inherited handling practices that are often harmful (Adhikari & Struwig, 2024; Salamandane et al., 2023; Wallace et al., 2022;). Consumer preference for informal markets, driven by accessibility, affordability, and cultural familiarity, sustains the demand (Kakaza & Naude, 2025; Kuboka et al., 2024). Yet vendors' marginal incomes preclude their investment in cold storage, potable water, or hygienic stalls. Formal market entry—carrying registration fees, taxes, and the spectre of punitive inspections—is perceived as a threat to fragile livelihoods, pushing actors deeper into unregulated spaces. Consequently, a vicious cycle that crystallizes infrastructure scarcity forces reliance on unsafe water and ambient storage, fueling spoilage and pathogen proliferation, and the resulting health and economic losses further impoverish vendors. The impoverishment locks them out of the investments needed for safety, with enforcement approaches that penalize rather than support cement informality.

Setting the Agenda for Food Safety Priorities in SSA

Addressing this challenge of foodborne diseases demands evidence-based interventions tailored to the realities of these complex food environments. To this end, we identify four urgent and interconnected research priorities.

First, researchers must characterize the distinct health risks embedded in diverse informal settings by shifting from top-down assessments to participatory methods, such as participatory action research, storytelling, and participatory GIS mapping, that position informal actors as co-producers of knowledge and capture contextual nuances (Barker et al., 2010). Second, a systems lens is essential for moving beyond siloed, vendor-focused studies. Whole-chain approaches, including farm-to-fork and One Health frameworks, can reveal how practices from producers to consumers interact, equipping policymakers with holistic insights to design adaptable, impactful regulations (Brouwer et al., 2020; Rodríguez-Melcón et al., 2024).

Third, context-specific investigations on governance must dissect the incentives and institutional failures that undermine enforcement and compliance. Tracing outbreaks and upholding standards remain exceedingly difficult, and draconian enforcement often backfires. Place-based research should uncover how to foster environments that encourage systemwide ownership of safety regulations, thereby guiding officials toward interventions with genuine stakeholder buy-in. Finally, research must drive the co-design and adoption of appropriate infrastructure. Deploying contextually relevant solar-powered cold storage, dryers, and preservation facilities in off-grid communities, where most aquatic foods, fruits, and vegetables originate, can radically reduce post-harvest losses and safeguard public health. Collectively, these integrated efforts will empower decision-makers to transform food safety in Africa's informal markets.

Conclusion

Overall, the health risks to consumers and food system actors remain an understudied issue in SSA. We posit the need for investments and support for research programs that extend the existing knowledge base and produce policy-relevant insights on the different forms of risk in the local food environment in SSA. Such research frontiers support effective policymaking that responds to the unique needs of actors in informal food environments and will help trace outbreaks and minimize food-related illnesses and vulnerabilities in SSA.

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Challenges and complexities in Northern food systems: Mapping food access and decision-making in Nunavik

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Abstract

The Canadian Arctic and sub-Arctic are undergoing rapid ecological, social, and political transformations that profoundly affect local food systems. This study examines how households in Nunavik, Canada, navigate their complex, mixed subsistence and market-based food systems and identifies the

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factors shaping decision-making when selecting food sources. Specifically, this study asks: (1) What are the primary food acquisition sources for households, how are they accessed, and what challenges are faced? and (2) What key factors influence household decision-making in selecting food acquisition sources? Using a co-production of knowledge approach, participatory workshops were conducted with 17 community members from five Nunavik communities. Data included co-created conceptual food system maps, participant-placed preference cards, and facilitator notes from scenario-based discussions. Findings were subsequently validated in a follow-up community engagement session. Thematic qualitative analysis revealed that Nunavimmiut households draw on over 13 distinct food acquisition sources, ranging from direct harvesting and community freezers to grocery stores, family and friends, and increasingly, social media platforms that facilitate both sharing and informal markets. High costs of food and fuel, transportation barriers, time constraints, and other social factors emerged as persistent challenges. Income level and the presence of a skilled hunter strongly influenced decision strategies: low-income households without hunters relied heavily on community freezers and kin networks, while higher-income households accessed additional options such as buying country food from Inuit harvesters and southern grocery stores. These results underscore the adaptive capacity of Nunavik's food systems alongside their sensitivity to economic and environmental disruptions. Further, these results point to the importance of addressing both structural barriers and digital access. Policies that enhance community freezers, transportation, food assistance programs, and culturally grounded digital tools can strengthen food security and resilience. This study highlights the value of interdisciplinary, community-based approaches that integrate cultural preferences, economic dimensions, and social networks in supporting Arctic food systems under conditions of rapid change.

Keywords
Nunavik, Arctic food security, co-production of knowledge, participatory methods, food system mapping, Inuit food systems

Introduction
The Canadian Arctic and sub-Arctic are experiencing rapid and complex changes that are profoundly impacting the daily lives of their residents, espe-

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Disclosures
The authors used Grammarly as a writing-support tool during manuscript preparation. Grammarly may use artificial intelligence to provide suggestions related to grammar, clarity, and sentence structure. No AI tools were used to generate original research findings, analyze data, or make substantive scientific interpretations. All AI-assisted suggestions were reviewed and approved by the authors, who take full responsibility for the final content of the manuscript.

cially regarding access to food. Environmental change is altering the region's weather patterns, landscapes, and ecosystems. Socio-economic factors, like population growth, increasing resource development, and intensified interest in energy, tourism, and fisheries, are reshaping the economic fabric of these communities, while cultural values and knowledge remain strong and anchored (Ford et al., 2021; Larsen & Fondahl, 2015; Lovecraft & Eicken, 2011). Indigenous communities, while striving to enhance their sovereignty and self-governance, face unique challenges as these transformations influence their access to primary food sources. These challenges are compounded by the historical and ongoing effects of colonization on Indigenous land rights and food sovereignty. For Arctic residents, who often rely on a combination of traditional and market-based food sources, these changes raise critical questions about food security.

Despite the urgency of these issues, there is limited research that examines how environmental change and development pressures are affecting food systems in Arctic and sub-Arctic regions. This paper defines food systems as the interconnected networks of stakeholders, including communities, institutions, and organizations, that are involved in producing, distributing, and consuming food in these regions (Rastoin & Ghersi, 2010). Indigenous food systems, in particular, represent complex relationships that incorporate traditional practices, knowledge, and cultural significance, encompassing the gathering, harvesting, and preparation of food with a reliance on local biodiversity and traditional ecological knowledge (Kuhnlein et al., 2009). As the landscapes, ecosystems, and social structures of these regions evolve, so too do the challenges to sustaining these food practices and ensuring food security.

Food systems can be considered a type of social-ecological system (SES) (Allen & Prosperi, 2016). Berkes and Folke (1998) first introduced SES to describe how humans' social systems and the surrounding natural environment interact. An SES lens recognizes that environments are embedded within complex systems that include regional and global influences and multilayered governance structures. Previous researchers have utilized SES approaches to demonstrate the complex interlinkages within food systems and food security outcomes in Northern regions (Fauchald et al., 2017; Hopping et al., 2010; Kenny, 2017; Zimmermann et al., 2023). An SES approach recognizes that the sustainability of food systems—and therefore the food security of communities dependent on them—is influenced by a wide range of social, economic, institutional, and ecological variables (Colonna et al., 2013).

Arctic and sub-Arctic food systems are shaped by unique geographical, environmental, and cultural factors. Inuit food systems rely heavily on traditional foods that are seasonal and influenced by climate and animal migration, requiring traditional knowledge for hunting and gathering (Ford, 2009; Kenny, 2019; Revenko & Soldatenkova, 2022; Wilson et al., 2020; Zimmermann et al., 2023). However, high transportation costs, limited employment opportunities, and limited access to fresh products contribute to food insecurity, with many relying on cheaper, nutrient-poor store-bought foods (Kuhnlein & Receveur, 2007; Little et al., 2021; Naylor et al., 2023). Environmental change further threatens these systems by, for instance, disrupting wildlife and hunting grounds and altering the population size of key species (Brockington et al., 2023; Ford, 2009; Kenny, 2019; Revenko & Soldatenkova, 2022; Wilson et al., 2020; Zimmermann et al., 2023).

The structure and function of food systems directly shape food security outcomes, determining who can access food, how reliably, and in what cultural context. Food security can be defined and quantified in many ways. However, Inuit-based organizations have worked to define food security in their own image. For example, a common definition created by the Inuit Circumpolar Council (ICC) is "the natural right of all Inuit to be part of the ecosystem, to access food, and to care for, protect, and respect all forms of life, land, water, and air" (ICC-Alaska, 2015). This definition emphasizes the ability of Inuit to obtain, process, store, and consume sufficient amounts of healthy and nutritious food that is culturally significant and spiritually needed. It encompasses the responsibility to pass on knowledge to future generations and highlights the connections among food, cultural identity, and environmental health. Furthermore, six

interconnecting dimensions of food security are identified by the ICC: (1) Food Availability, (2) Inuit Culture, (3) Decision-Making Power and Management, (4) Health and Wellness, (5) Stability, and (6) Accessibility. The ICC notes that without food sovereignty, food security cannot exist (ICC-Alaska, 2015). Additionally, complementing this ICC framework, Inuit Tapiriit Kanatami's Inuit Nunangat Food Security Strategy (INFSS) further situates food security within a rights-based and systems-level context. The strategy adopts the Food and Agriculture Organization of the United Nations' (FAO) globally recognized definition of food security, which states that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization of the United Nations [FAO], International Fund for Agricultural Development [IFAD], UNICEF, World Food Program [WFP], & World Health Organization [WHO], 2025, p. 177). Unlike narrower definitions that focus solely on food availability, the FAO standard has evolved to incorporate dimensions such as agency, stability, sustainability, access, availability, and utilization, making it one of the most comprehensive and widely applied international frameworks (High Level Panel of Experts on Food Security and Nutrition [HLPE], 2020). The INFSS applies this definition to the unique realities of Inuit Nunangat, where food systems depend on a combination of country foods, commercial fisheries, and store-bought foods. (Country foods refer to traditional foods derived from locally or regionally harvested aquatic and terrestrial wildlife, fish, and plants.) It also identifies the structural drivers of food insecurity such as poverty, high living costs, climate change, and diminished Inuit self-determination. It calls for coordinated, Inuit-led actions to advance food sovereignty across Inuit Nunangat (ITK, 2021).

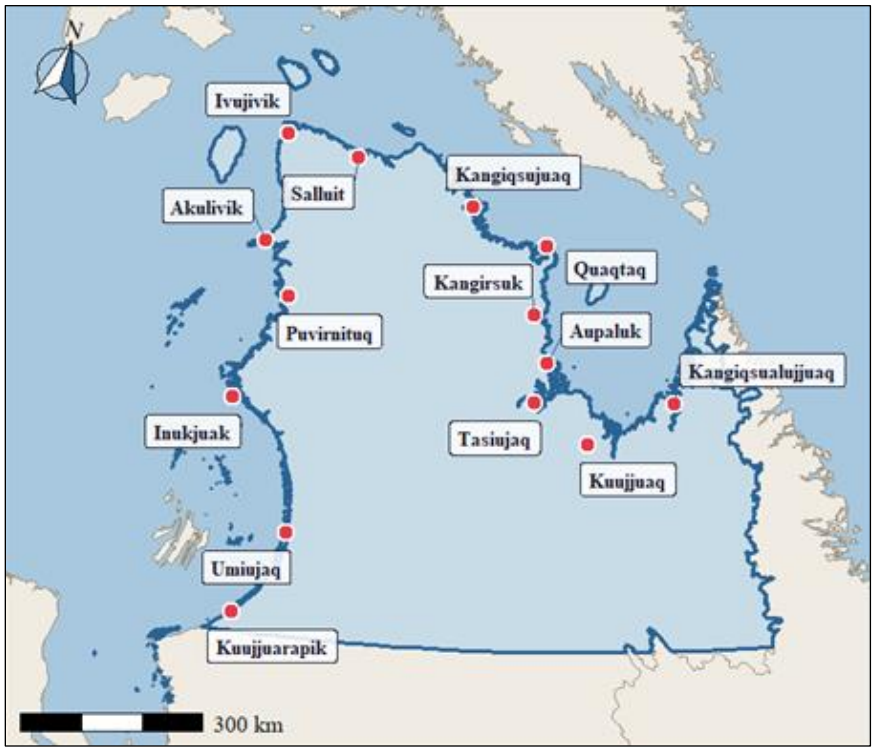
Despite a growing awareness of food insecurity issues in Arctic and sub-Arctic regions, research has yet to fully explore the intricacies of household-level decision-making in navigating Northern food systems, particularly under the combined pressures of environmental change and socio-economic development. While previous studies have utilized an SES approach to examine food security in these regions, there remains a critical gap in describing how individual households in Indigenous communities, such as those in Nunavik, Canada, access and choose their food sources, as well as the specific barriers they encounter in the process (Brockington et al., 2023; Kenny, 2017; Zimmermann et al., 2023). This research addresses this gap by employing a co-production of knowledge approach to examine two key questions: (1) What are the primary food acquisition sources for households in Nunavik, how are they accessed, and what challenges arise in doing so? and (2) What factors influence household decision-making when selecting food acquisition sources?

Methods

Study Context: Food Systems in Nunavik, Québec

Nunavik is an Inuit land claim settlement area in Northern Québec and contains 15 communities. These communities are all fly-in fly-out, meaning that there is no road or rail connection to each other or to communities in the south (Figure 1). Nunavik was politically and legally recognized after many years of negotiations between the Government of Québec, the federal Canadian government, a Canadian crown corporation (Hydro-Québec), and the Inuit and Cree. This resulted in the James Bay and Northern Québec Agreement (JBNQA) of 1975, the first modern land claims treaty in Canada. The JBNQA applies to mainland Nunavik, which is still considered part of the province of Québec, but it operates through nested sovereignty and nested federalism, a governance structure in which multiple overlapping levels of jurisdiction, including federal, provincial, and Indigenous authorities, operate simultaneously in the same territory (Wilson et al., 2020). The Nunavik Inuit Land Claims Agreement (NILCA), for its part, applies on the offshore Nunavik, what is referred to as the Nunavik Marine Region (NMR); this agreement came into effect in 2007 and was signed by the governments of Canada, Nunavut, and the Makivik Corporation (Makivvik).

Figure 1. Map of Nunavik and its Communities



The Nunavik Marine Region Wildlife Board (NMRWB) was established under to the NILCA to serve as the main instrument of wildlife management in the NMR. Its management decisions are made in consideration of both traditional Inuit Knowledge, especially from the Anguvigaq, and western science. The board comprises members from four parties:; Makivvik, Fisheries and Oceans Canada, the Department of Environment and Climate Change Canada, and the government of Nunavut. Among its various responsibilities under the NILCA, the NMRWB has sole authority to establish, modify, or remove levels of total allowable take or harvesting for all species in the NMR, modifying these from time to time as circumstances require.

Food systems in Nunavik operate on a mixed economy in which Nunavimmiut (Inuit from Nunavik) consume both country foods and market foods (see Table 1). The availability and consumption of these foods can vary between communities due to differences in the availability and abundance of local species. For instance, beluga is more commonly consumed by communities in the Hudson Strait region than the Hudson Bay (Allaire et al., 2021). Additionally, some country foods are more accessible than others in terms of the effort and resources required to harvest them. For example, harvesting fish and berries involves different time commitments, ecological knowledge, and coordination than pursuing larger species like caribou or marine mammals, which often require multiple harvesters and extended periods away from the community. There is also a temporal component, as certain country foods are only available during certain times of the year.

While country foods are harvested locally, an individual household may obtain food in many ways. Besides direct harvesting, a household may also receive country foods through a friend or relative in the community or region, or from other regions. Food-sharing networks are an important part of Inuit culture. According to the 2017 Qanuippitaa? regional health survey, 93% of Nunavik households reported giving food to one

Table 1. Country Foods and Market Foods Consumed in Nunavik Based on Allaire et al. (2021)

Country Foods	Market Foods
beluga, seals, walrus, caribou, polar bear, muskox, partridge, goose, arctic char, salmon, trout, pike, walleye, whitefish, sculpin, mollusks, clams, scallops, whelks, seaweed, and berries	vegetables, fruit, processed meat, red meat, chicken, turkey, eggs, canned fish, legumes, bread, pasta, nuts, milk, yogurt, and cheese

or more other households, while 86% of individuals reported receiving food from others (Allaire et al., 2021). Additionally, there are government-sponsored programs for country foods, such as community freezers and hunter support programs (Kishigami, 2000; Ramirez Prieto et al., 2024). These programs hire local hunters and pay for their supplies so they can hunt on behalf of the community. The hunter support program can also help facilitate the delivery of country foods between communities if one community is having difficulty hunting.

Market foods consumed in Nunavik are purchased at local grocery stores or obtained through outshopping (ordering food from southern retailers for delivery to the community). All communities have a community-owned co-op store, and 10 of the 15 communities have a store operated by the Northwest Company. However, nutrient-dense market foods are often very expensive, and households with lower socioeconomic capacity tend to eat more processed, less nutritious market foods, which have been associated with negative health consequences such as obesity, diabetes, and hypertension (Kuhnlein & Receveur, 2007; Little et al., 2021).

Despite the diversity of food sources available to Nunavimmiut, food insecurity remains a pressing issue in Nunavik, driven primarily by economic barriers that include high food costs, limited employment opportunities, and low household incomes—factors that restrict access regardless of food availability (Naylor et al., 2023). More than three-quarters of Nunavimmiut (78%) reported experiencing some level (marginal, moderate, or severe) of food insecurity in 2017. Food insecurity was associated with certain social and economic factors (Furgal et al., 2021). For example, food insecurity was more common among youth (aged 16 to 19) than adults or Elders, among individuals that make less than 40,000 CAD a year, and in communities in the Hudson Bay region (Furgal et al., 2021).

Participatory Workshops as Tools to Co-Produce Knowledge

Community members in Nunavik, like other Arctic and sub-Arctic communities, possess a deep, multigenerational, and locally specific knowledge (Berkes et al., 2007; Tremblay et al., 2006). Local knowledge is the collective knowledge held by local people over time through their experiences, observations, and interactions with their surroundings (Warburton & Martin, 1999). Traditional or Indigenous Knowledge includes culturally rooted practices (Bruchac, 2014). In the North, there is also Inuit Qaujimajatuqangit (IQ) which refers to the collective body of Inuit knowledge, values, and worldviews developed through generations of lived experience on the land (Karetak et al., 2017).

Historically, the integration of local or traditional knowledge into scientific research was absent (Fischer, 2000). When the value of this knowledge was eventually recognized by the academic scientific community, it was often collected in an extractive and exploitative manner. This practice—commonly referred to as "neo-colonial," "helicopter," "parachute," or "hit-and-run" research—resulted in the appropriation of local knowledge without equitable benefits or involvement of the communities themselves (Graugaard, 2020; Stefanoudis et al., 2021). This extractive approach has perpetuated colonial dynamics and strained the trust between scientific researchers and Indigenous communities, hindering the potential for meaningful collaboration.

Recognizing the shortcomings of extractive research, a shift toward collaborative, community-based research that co-produces knowledge with and for a community has gained traction. This approach emphasizes partnership and shared decision-making between scientists and community members (Berkes et al., 2007; Yua et al., 2022). Co-production of knowledge acknowledges the importance of diverse knowledge systems and aims to create research that is relevant, inclusive, and beneficial to all stakeholders (Armitage et al., 2011). By working collaboratively, researchers and community members can bridge the gap between scientific understanding and Indigenous knowledge, leading to a more holistic comprehension of complex issues.

Participatory workshops are one way that knowledge can be co-produced with community partners (Djenontin & Meadow, 2018). Workshops can be defined as arranged events of limited dura-

tion where participants with a common domain, field, or agenda come together to actively participate, influence the workshop's direction, and practice relevant techniques, skills, and situations (Ørngreen & Levinsen, 2017). Workshops are conducted by individuals experienced in the domain and are designed to promote genuine participation, with small participant groups allowing for personal attention and active engagement. The expected outcome of such workshops includes generating new insights and collaborative understandings related to complex social-ecological processes. Participatory workshops have been used effectively in Nunavik and broader Arctic contexts to co-produce knowledge about food systems, ecosystems, and community futures, including through scenario co-development processes with Nunavimmiut communities (Falardeau et al., 2019, 2025).

Developing a participatory workshop on food systems in Nunavik

The purpose of this workshop was to co-produce with Nunavimmiut a general description of the food system of a typical household in Nunavik, while recognizing that every community has unique assets, histories, infrastructures, programs, and challenges that no single general model can fully capture. Nonetheless, such a description provides a valuable foundation for understanding broad patterns in how households access food and the barriers they face across the region. Specifically, this workshop sought to better understand the various food acquisition pathways that a typical household interacts with, the challenges associated with accessing these pathways, and how various social and environmental conditions shape household decision-making within this food system.

The workshop proposal received institutional review approval from the Centre Hospitalier Universitaire (CHU) de Québec Université Laval (SIRUL 128984). To gain this approval, researchers first consulted with various community partners about the workshop idea. Particularly, researchers spent months discussing this workshop with the Anguvigaq, Nunavik Marine Region Wildlife Board (NMRWB), Kativik Regional Government (KRG), Makivvik Corporation, Nunavik Regional Board of Health and Social Services Nunavik Nutrition (NRBHSS), and Nunavik Nutrition and Health Committee (NNHC) to gain their support and invitation letters. This process helped ensure that participants were safeguarded, their knowledge and time were respected, and this work would benefit the Nunavimmiut.

In November 2023, a workshop was held in Kuujjuaq, Nunavik (Québec) as part of the "Sustainable and resilient country food systems for future generations of Nunavimmiut—Promoting food security while adapting to changing northern environments" project funded by Sentinelle Nord (the principal investigators [PIs] were authors Kenny and Maps). The workshop included 17 community members across five communities (Kuujjuaq, Kangirsuk, Chisasibi, Kangiqsualujjuaq, and Kangiqsujuaq), as well as two interpreters. Ten participants identified as female and seven as male. Participants represented Elders, youth, harvesters, heads of households, and Inuit employees of regional organizations. Participants were recruited by sending invitation letters through the community partners previously consulted, who then disseminated these letters to individuals within their networks.

The workshop lasted two days, during which various activities were facilitated so that information could be gathered about the local food system, food preferences, and common challenges faced when trying to acquire food. The workshop was held in English with Inuktitut simultaneous interpretation and text written in Inuktitut syllabics. Specifically, the workshop engaged participants in two key tasks directly aligned with the study's research questions. First, participants mapped a conceptual food system and identified challenges within it, addressing the objective of understanding the primary sources of food for households, how they access these sources, and the barriers they face. Second, through participatory scenarios, the workshop explored household decision-making processes in acquiring and consuming food, providing insights into the key factors that influence these decisions. The step-by-step protocol for these activities can be found in the Appendix.

Consistent with the National Inuit Strategy on Research (ITK, 2018), which affirms Inuit ownership, access, and control over data derived from

their peoples and lands, findings were shared back with participating communities and regional partners prior to publication, and feedback from these engagements was meaningfully incorporated into the final manuscript. Raw data that include workshop maps, notes, and recordings are held securely by the research team and will be shared proactively with community partners and regional organizations; any future use or reanalysis requires explicit free, prior and informed consent (FPIC) from the relevant communities. It is worth noting that at the time of this research, Nunavik lacked a centralized research governance mechanism—a gap the emerging organization Atanniuvik[1] is being established to address, with a mandate to oversee research review and approval in a manner grounded in Nunavik Inuit self-determination (Atanniuvik, n.d.).

Map a conceptual food system and identify challenges within that system

Food system mapping is an approach used to identify all stakeholders, institutions, goods, activities, food flow rates, and policy, economic, and environmental characteristics within a food system (Allen & Prosperi, 2016; Jacobi et al., 2019). In this activity, participants were separated into two groups based on whether their community was based on the Ungava Bay/Hudson Strait area or the coast of the East Hudson Bay. Each group was given a large piece of paper, "Food Location Cards," two different colored markers, and yellow triangle "Challenge" tokens (Figure 2). The "Food Location Cards" represented places where a household might get food (the environment, grocery store, friend's house, etc.). The Challenge tokens represented the difficulties (e.g., time, money, knowledge, etc.) that households might face when trying to utilize these pathways.

Participants were asked, "where does a typical Inuk household get food from?" Then, they were instructed to draw the flow of food or pathway from these locations to the household and to identify if these flows were market foods or country foods using the two different color markers.

This activity was a deductive approach, as preconceived options for the Food Location and Challenge tokens were created based on literature, but community members were always encouraged to disclose new Food Locations or Challenges that were not provided.

Identify household decisions in acquiring and consuming food through participatory scenarios

The next activity used the food system conceptual maps created in the first activity (Figure 2) in conjunction with provided scenarios to understand

Figure 2. Examples of the Food Systems Maps Generated in Response to the Question, "Where does a typical Inuk household get food from?"

[1] https://atanniuvik.ca

how a household would make decisions about where to acquire food based on the scenario (Figure 3). While scenario planning has roots in military strategy and business (von der Gracht, 2008), it has more recently been applied to investigate community systems (Bennett et al., 2016; Brown et al., 2016; Flynn et al., 2018; Ogilvy, 2002; Rawluk & Godber, 2011; Zapata & Kaza, 2015), including in Nunavik (Falardeau et al., 2025).

Each group was given 10 "Order Cards" labeled 1 to 10. These numbers represented first choice, second choice, third choice, etc., for where a household would go to acquire food for the given scenario (e.g., through harvesting, the Co-op store, etc.). Ten cards were chosen because that is considered the upper end of the maximum cognitive load that humans can effectively manage and prioritize around (Miller, 1956). Each group was presented with four scenarios and asked to rank their preferences for acquiring food by placing the preference cards on the food location cards. The following scenarios were given:

1. What is the first place, second place, third place, etc., that a typical Inuk household would get food from *if* the household had *low income* and *no hunter*?
2. What is the first place, second place, third place, etc., that a typical Inuk household would get food from *if* the *community freezer were broken*?
3. What is the first place, second place, third place, etc., that a typical Inuk household would get food from *if* the household had *high income* and *not very skilled hunter*?
4. What is the first place, second place, third place, etc., that a typical Inuk household would get food *if* there was an *extended period of poor harvest* by hunters in the community?

Only four scenarios were able to be explored due to time constraints. However, these scenarios were selected because previous work has suggested that income, status of a hunter, and country food availability were key determinants of food security (Allaire et al., 2021, Gilbert et al., 2021). The research team acknowledges the cultural sensitivity surrounding harvesting capacity and food security in Inuit communities, where hunting is a deeply valued source of cultural identity and pride. To navigate this sensitivity, scenarios were deliberately framed around 'a typical Inuk household' rather than directed at individual participants. This approach draws on established qualitative research methodology suggesting that hypothetical, third-party framing reduces social desirability bias by making responses less self-implicating, thereby allowing participants to discuss sensitive topics more openly and candidly (Bergen & Labonté, 2019; Fisher, 1993; Ried et al., 2021)

Figure 3. An Example of the Food System Map Being Used with the "Order Cards"

Data Analysis

Thematic qualitative anal-

ysis was used to evaluate both the conceptual food system maps and the decision-making processes associated with each scenario. Thematic analysis is a flexible and widely used qualitative method that systematically identifies, analyzes, and interprets patterns or themes within qualitative data (Riger & Sigurvinsdottir, 2016). This approach supports the examination of complex datasets by capturing both explicit and implicit meanings, thereby facilitating a detailed understanding of participants' experiences and perspectives. By organizing large volumes of qualitative information into coherent themes, thematic analysis enables the synthesis of key insights and allows for comparison across groups and scenarios (Riger & Sigurvinsdottir, 2016).

Analysis followed a multistage, iterative process. Initial familiarization with the data involved repeated review of digitized photographs of the conceptual food system maps, participant notes, and preference cards to ensure comprehensive contextual understanding. Open coding was then conducted, with initial codes assigned to distinct concepts, relationships, and decision factors evident in the materials. These codes were subsequently grouped into broader categories based on conceptual similarity and recurrence across groups and scenarios. All coding was conducted by the first author, with codes and emerging themes subsequently reviewed by the broader research team to ensure consistency and interpretive rigor. Any discrepancies or differences in interpretation were resolved through iterative discussion until consensus was reached. Through iterative refinement, categories were merged, revised, or expanded to develop a final set of overarching themes that represented key components of the food system and the primary factors influencing food acquisition decision-making.

Data Validation

In May 2025, preliminary findings from the workshop were shared during a follow-up community engagement event in Kuujjuaq to support validation of the results. It was facilitated by a local community member with extensive experience in local food system research. The session included seven community members, two of whom were Elders, while five identified as primary household members responsible for food preparation and acquisition. During this engagement, the conceptual food system model and decision-making tree were presented and discussed. Participants indicated broad agreement with the overall findings but noted that social media plays a more significant role in food acquisition than was captured in the initial analysis. Additionally, participants emphasized that decision-making pathways vary substantially across communities, reflecting local contexts and constraints. These insights were incorporated into the final conceptual models and results.

Results

Conceptual Food System: Where does a typical Nunavimmiut household get food from?

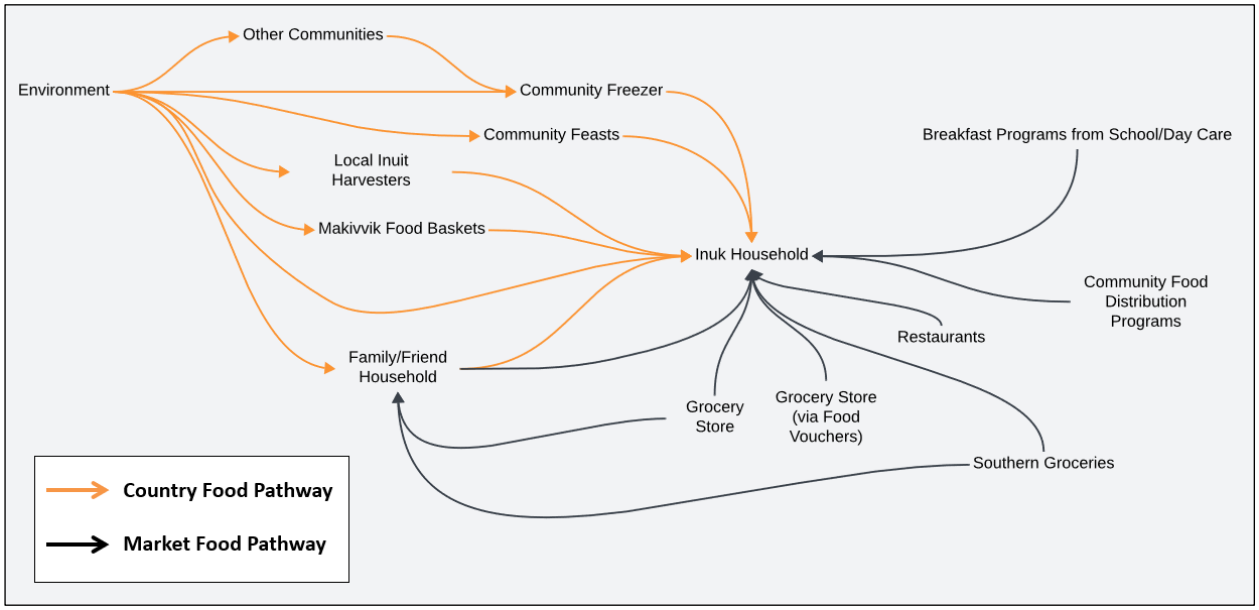
The food system for a typical household is complex. When the workshop maps were combined and simplified, the conceptual food system mapping exercise revealed 13 distinct food sources: the environment, other communities, community freezer, from local Inuit harvesters, Makivvik food baskets, family/friend households, grocery stores, southern grocery stores, food programs (food banks/soup kitchens), breakfast programs, food vouchers, community feasts, and restaurants (Figure 3).

Households obtain country food through multiple avenues, with the natural environment being the primary source acquired via harvesting (Figure 4). Households possessing the necessary resources engage directly in harvesting from the environment. Another source is the community freezer, supplied by community hunters employed through the Hunter Support Program, which also facilitates the transport of harvests from other communities. Local Inuit harvesters, skilled individuals who provide additional country food, are supported by households lacking their own hunter or having less skilled household hunters. Community feasts, held several times a year for cultural reasons and sponsored by community hunters and the Hunter Support Program, serve as another source of country food. Additionally, Makivvik annually provides 1 kg (2.2 lbs.) of shrimp to each household around Christmas in addition to other food gift baskets.

Market foods are acquired through various

Figure 4. A Simplified Food System Map Showing All the Different Ways a Typical Inuk Household in Nunavik May Acquire Food

The orange arrows represent country food flows or pathways, and the black arrows represent market food pathways.



means, including local and southern grocery stores, government programs, and community resources (Figure 4). All communities have a Co-op store and a Northern Store as common market food sources. Southern grocery stores play a role for households with members who often travel south for work, as they often shop in the South where it is less expensive and return with groceries. Government programs contribute to market food availability. For instance, breakfast programs offer meals at local schools for children. Also, the food voucher program, sponsored by Local Community Services Centres (CLSCs), provides qualifying individuals with vouchers to purchase food at grocery stores. Food banks and soup kitchens offer additional support. While less commonly used, restaurants serve as a source of market food for younger individuals or special occasions, although not all communities have restaurants.

Notably, family members' and friends' households occupy a unique place in the food system, as they provide both country food and market food. This dual role underscores their importance in the overall food network and the community's reliance on both types of food sources.

Lastly, the role of social media emerged as an important conduit for accessing both country and market foods. Participants underscored the centrality of social media platforms, particularly Facebook community groups and local WhatsApp chats, as informal marketplaces and sharing hubs. These platforms were used to (1) announce the availability of country food (e.g., caribou, char, seal meat) for sale or trade; (2) coordinate sharing of harvested foods among kin or neighbors; (3) advertise grocery store sales; and (4) circulate information about food program sign-ups, freezer status, or feast dates. In practice, this meant that households without direct harvesting capacity could still access country foods by quickly responding to posts, while those with excess catch could redistribute efficiently.

What are the challenges when interacting with the food system?

Participants identified several challenges in accessing food, with high costs and transportation barriers being the most noteworthy. All participants emphasized the extreme cost of living in the North, particularly the high prices of food and fuel. Transportation impeded access to both country foods and market foods across nearly all the identi-

fied food pathways. Households lacking access to transportation or disposable income for fuel often struggle to make trips to grocery stores or government-supported food locations like food banks.

Time constraints also pose substantial challenges to food acquisition, especially for households with members holding office jobs or having childcare responsibilities, making it difficult to allocate time for harvesting activities. Hunting may require individuals to leave home for days, which is hard to accommodate with fixed work schedules. Consequently, households wanting to harvest may be prevented due to the absence of a hunter, limited time, lack of transportation, or high fuel and equipment costs.

While community resources like the community freezer and the broader Hunter Support Program are valuable, they face limitations that hinder their effectiveness. The community freezer sometimes breaks down or runs out of food quickly, preventing everyone from obtaining country food. The Hunter Support Program's capacity to deliver country food from other communities is limited by its annual budget from the Kativik Regional Government. Additionally, hiring local Inuit harvesters is generally accessible only to high-income households.

Social factors also shape food access, with the strength and reach of social networks playing a central role in determining what food sources households can draw upon. Community feasts and the annual Christmas baskets from Makivvik, often containing 1 kg of shrimp, were positively viewed by participants but recognized as providing only short-term, supplementary support. Acquiring food from family or friends is an important pathway for many households, but can be challenging when social connections are limited, when family members have relocated to other communities, or when households occupy different social positions within the community. Additionally, while community-based food distribution programs such as food banks and soup kitchens provide support in some communities, participants noted that these programs are not consistently available across Nunavik. Additionally, a lack of awareness about government programs further hinders households from accessing available support. Participants noted that some households might not know how to enroll in programs like the food voucher system offered by the CLSCs, limiting their ability to benefit from these resources.

Participatory scenarios: What factors impact the decision-making process for Nunavimmiut when acquiring food?

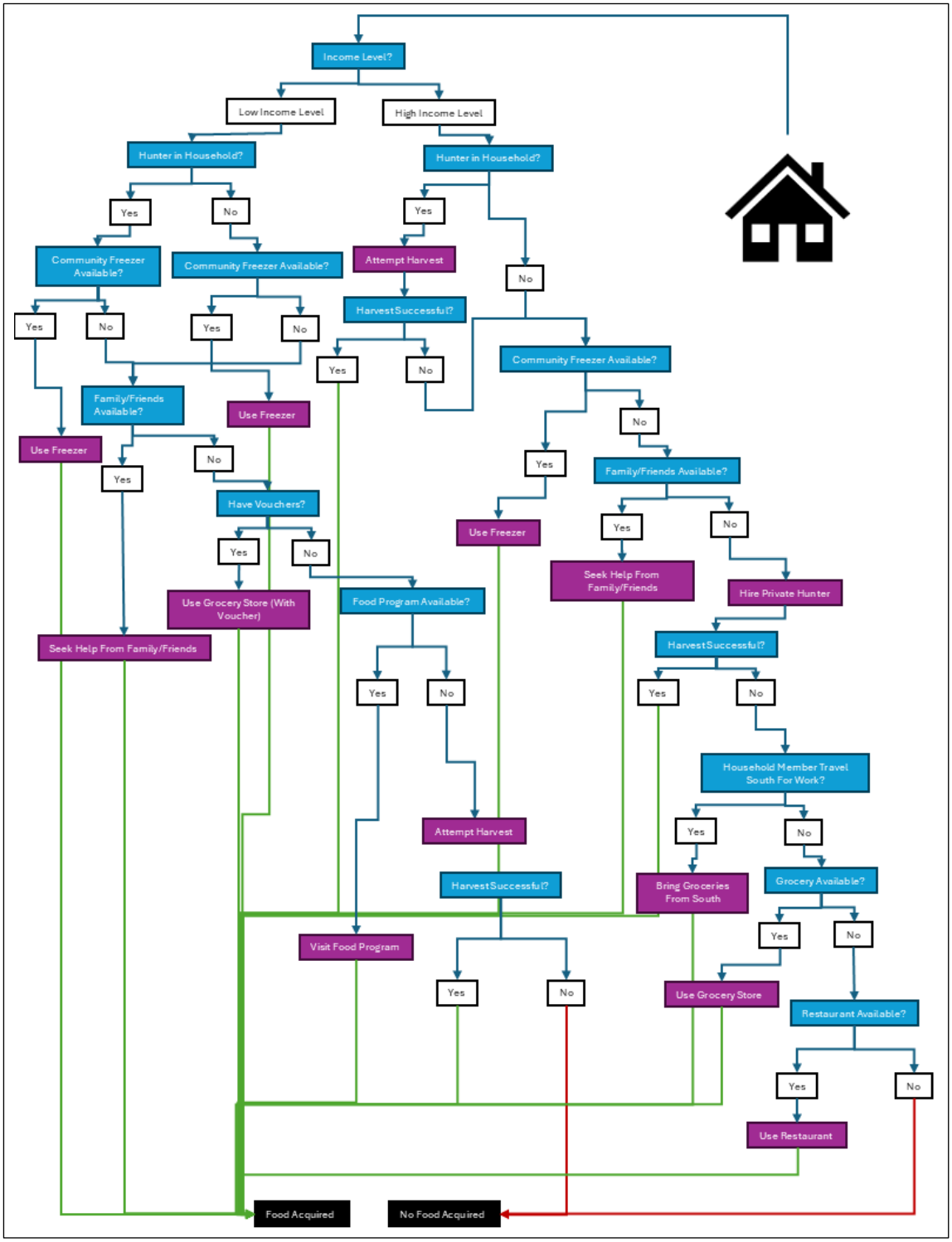
From the scenario exercises, insight was gained into how social and environmental factors impact the decision-making process for Nunavimmiut households when acquiring food (Figure 5). A major theme that emerged from the scenario exercises was the important roles that income and access to resources play in food acquisition. Low-income households without a hunter typically prioritize free sources of country food, with the community freezer being the first option. If the freezer is unavailable, these households rely on family or friends, a source which provides either country or market food at little to no cost (Figure 5). The grocery store is only considered when vouchers are available, and community distribution programs, like the food bank or soup kitchen, are only considered when available. As one participant explained, "We don't want to go to the food bank, but sometimes we have no other choice." This decision-making process highlights the economic constraints that shape the choices low-income households face.

In contrast, high-income households without a hunter have more options at their disposal (Figure 5). They also make use of the community freezer, but they can afford to hire local Inuit hunters if necessary. These households often travel south for work, purchasing groceries during these trips. Market foods from southern grocery stores, and even dining out, become accessible options when country food is scarce. One participant noted, "We bring back as much food as we can from the south, just in case the freezer runs out."

The presence of a hunter in the household, whether the household is low- or high-income, changes the decision-making process (Figure 5). Low-income households with a hunter prefer to rely on the community freezer first but will turn to harvesting if needed. However, harvesting is dependent on access to time, transportation, and

Figure 5. Decision-Making Flow Chart Illustrates the Factors Influencing How a Typical Inuk Household in Nunavik Determines Where to Acquire Food in Their Food System

Blue boxes represent key questions and conditions guiding the decision process, while purple boxes denote potential food sources. The decisions and conditions ultimately lead to food be acquired, following the green arrows, or not acquired, following the red arrows.



fuel. One participant said, "Having a hunter helps, but it's still expensive to go hunting, especially if the hunt isn't successful." High-income households with hunters prioritize harvesting country food themselves, but they also use the community freezer and may hire local Inuit hunters when needed. The ability to rely on these multiple sources emphasizes how the presence of a hunter, combined with household resources, diversifies food acquisition strategies.

A recurring theme was the reliance on social networks, such as family and friends, for both country food and market food. Households without access to hunters or facing shortages in community resources turn to their social circles to fill food gaps (Figure 5). However, participants also acknowledged that not all households have the same social connections, which can limit access to shared food. "If your family is in another community, it's harder to get help," one participant explained. This reliance on social networks highlights the co-produced nature of food security, where community ties are essential for navigating resource constraints. If a low-income household has a hunter, the process changes slightly. Participants expressed that they still prefer the community freezer for country food, but if it is unavailable, they would seek help from family or friends before attempting to harvest food themselves (Figure 4). The grocery store remains an option if other sources are exhausted, with the food bank or soup kitchen again being the last resort.

Environmental conditions and the reliability of infrastructure, like the community freezer, further complicate the decision-making process. When asked how food choices would change if the community freezer broke down, participants noted that high-income households would likely be in a position to buy country food from Inuit harvesters in their community or turn more to market foods, whereas low-income households would struggle, relying more heavily on family, friends, or food banks. As one participant reflected, "Without the freezer, we'd be in trouble. Those who can't afford to hunt would have little options for country food." Similarly, during periods of poor harvests, households would continue to attempt harvesting but place more hope on the Hunter Support Program to facilitate the restocking of community freezers from neighboring communities. High-income households would transition to market foods more easily, while low-income households would experience greater food security challenges, increasing their reliance on external support. Notably, across all scenarios and income levels, country food pathways were consistently prioritized over market food sources, with market foods emerging as a second choice only when country food options were exhausted.

It should be emphasized that this decision-making model represents a simplified, linear decision model generalized from a broad consensus derived from discussions with two different groups. While it is intended to model a typical Inuk household and a typical food system in the region, it is important to acknowledge that available resources vary greatly between communities. Moreover, decision-making processes are not strictly linear or always rational, and individual households may follow varied, context-specific pathways influenced by a range of social, economic, cultural, and environmental factors.

Discussion

Arctic and sub-Arctic food systems are experiencing profound transitions due to environmental change, evolving socio-economic landscapes, and intensified resource development (Ford et al., 2021; Larsen & Fondahl, 2015; Lovecraft & Eicken, 2011). These forces intersect with the cultural, economic, and environmental dimensions of food acquisition, making it critical to document how households navigate complex and dynamic food networks (Allen & Prosperi, 2016; Berkes & Folke, 1998; Kuhnlein et al., 2009). Applying an SES lens to Nunavik food systems proves particularly valuable here because it reveals the feedback loops and interdependencies that single-factor analyses would miss. For instance, a purely economic analysis would capture the role of income in shaping food access but would miss how environmental disruptions like poor harvests interact with infrastructure failures like broken community freezers to compound food insecurity for low-income households. Similarly, a purely ecological analysis would capture species availability but miss how social networks

and cultural values mediate whether and how households can access those species. The SES framework integrates these dimensions, allowing us to see household food acquisition not as a series of independent choices but as an adaptive response to a complex, dynamic system in which ecological, social, economic, and infrastructural factors are deeply intertwined.

The findings extend existing scientifically documented knowledge by demonstrating that households in Nunavik utilize a diverse array of food sources, including direct harvesting from the environment, using community freezers, buying country food from Inuit harvesters, buying from grocery stores, and utilizing social networks of family and friends. This complexity parallels earlier research in northern regions that emphasizes multifaceted and adaptive strategies for securing food (Ford & Beaumier, 2011; Ford, 2009; Gilbert et al., 2021). Despite this adaptability, over three-quarters of Nunavik inhabitants still experience food insecurity (Furgal et al., 2021), underscoring the persistent structural and economic hurdles that challenge both the sustainability of these food systems and the communities relying on them.

Revisiting themes introduced in our introduction, we find that barriers such as the high costs of food and fuel, limited transportation options, and time constraints due to employment or childcare responsibilities align with previous research identifying economic and logistical obstacles in Arctic regions (Brockington et al., 2023; Little et al., 2021). However, this study builds on these insights by illustrating how specific household characteristics—particularly income level and the presence of a skilled hunter—affect the strategies used to acquire food. Low-income households without an active harvester rely more heavily on community freezers, social networks, and community-based food distribution programs, like food banks or soup kitchens, whereas higher-income households can more readily hire Inuit harvesters or purchase nutritious and diverse market foods during travels to the South. This stratification in access patterns adds nuance to the documentation of the SES dynamics underlying Arctic and sub-Arctic food insecurity, extending beyond general economic constraints to highlight how cultural knowledge and social ties mediate these pressures (ICC-Alaska, 2015; ITK, 2021; Kuhnlein et al., 2009).

Our study also reinforces the cultural and nutritional significance of country foods, which participants consistently ranked as the most important food source despite their smaller fraction of total dietary intake in terms of energy or total grams consumed. This finding reaffirms that food security in Inuit communities is not solely about caloric sufficiency; it is deeply connected to cultural identity, the transfer of traditional knowledge, and the spiritual values embedded in harvesting and sharing practices (ICC-Alaska, 2015; Inuit Tapiriit Kanatami [ITK], 2021). The importance of social networks is particularly evident, as obtaining food from family or friends' households is common across all income levels. This culturally ingrained sharing economy, noted in previous research (Collings et al., 1998; Kishigami, 2000; Quintal-Marineau & Wenzel, 2019; Ready & Power, 2018), not only helps mitigate food insecurity but also underlines how values of reciprocity, community cohesion, and cultural continuity are crucial components of Arctic and sub-Arctic food systems.

In terms of adaptive responses to disruptions, be they environmental (e.g., poor harvests, changing species migration patterns) or infrastructural (e.g., broken community freezers), households exhibit varying degrees of resilience and vulnerability. High-income households tend to offset disruptions by relying on local Inuit harvesters or market-based foods, while low-income households turn more intensely toward social networks, community support services, and cheaper, though often nutrient-poor, store-bought foods. This pattern resonates with previous findings indicating that environmental stress often leads to greater reliance on market foods, whereas economic stress pushes households to depend more on country foods and reciprocal sharing arrangements (Ford & Beaumier, 2011; Ford, 2009; Gilbert et al., 2021). For many households regardless of income level, community food programs, like school breakfast programs, represent an important safety net. Our results also showed that other food programs, like food banks, are valued although inconsistently available. This aligns with other research documenting the importance of community food programs as safety

nets for food-insecure households in Arctic communities, although uptake and availability may differ between larger regional centers and the smaller communities of Nunavik (Ford et al., 2012, 2013). The interplay of these strategies underscores the adaptive capacity inherent in Arctic communities and clarifies how SES frameworks can capture the feedback loops, trade-offs, and coping mechanisms that shape community resilience and vulnerability.

Our work also documented that the expanded role of social media has important implications for understanding Nunavimmiut food systems. While traditional sharing networks remain foundational, digital platforms may act as accelerators, broadening the reach of reciprocity and lowering the transaction costs of coordination. This "digital layer" could make the food system more adaptive to disruptions (e.g., freezer breakdowns, poor harvests) by providing real-time information on alternative sources. However, reliance on social media may also create inequities. For instance, Elders or households without reliable internet access risk exclusion, and the monetization of some exchanges blurs the line between sharing and commerce. Future interventions should therefore consider digital access as a determinant of food security, alongside physical infrastructure and economic resources.

This study has several limitations that should be acknowledged. First, while 10 of 17 participants identified as female, this study did not conduct a systematic gender analysis of food acquisition patterns. Given that harvesting practices, food preparation, and household food management are often gendered activities in Inuit communities, future research should more explicitly examine how gender shapes food access and decision-making. Second, this study provides a snapshot of food system dynamics at a single point in time and does not include historical comparisons that would allow for examination of how food acquisition patterns have shifted in response to climate change or socio-economic transformations over time. Longitudinal research would strengthen understanding of these dynamics. Third, the participatory workshops were held in Kuujjuaq, and, while participants were recruited from five communities, the findings may not fully capture the diversity of food system experiences across all communities in Nunavik, each of which has unique assets, histories, and challenges. Finally, the preconstructed nature of the Food Location Cards and scenario exercises reflects a deductive approach that may have constrained participants from raising food sources or decision-making factors not anticipated by the research team.

Conclusion

This research maps complex food acquisition pathways and identifies multilayered economic, cultural, and infrastructural barriers, providing a foundation for informed policy interventions. Strengthening community-based harvesting programs, improving transportation infrastructure, and increasing budgets and maintenance for community food initiatives (e.g., Hunter Support Programs and community freezers) all have the potential to enhance food security across Nunavik. These recommendations align more broadly with the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), particularly Article 21, which affirms the right of Indigenous peoples to the improvement of their economic and social conditions, including food security (UN General Assembly, 2007). Situating our findings in this international rights-based framework underscores that food insecurity in Nunavik is not simply a logistical or economic challenge but a matter of Indigenous rights.

Addressing these challenges is critical, particularly as rapid environmental and socio-economic changes continue to reshape Arctic and sub-Arctic food systems. This work underscores the ongoing need for community-based, participatory approaches that center Inuit knowledge, cultural preferences, and social networks in food security research and policy, and demonstrates the value of such approaches in generating actionable, locally grounded insights.

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Sociodemographic correlates of food security status among older adults in central Ohio: Toward a typology of risk

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Abstract

Vacillating trends in the prevalence of food insecurity (FI) have been observed in the U.S. While a decline occurred post-pandemic, the cessation of government assistance programs in 2023 resulted in increased prevalence, particularly among older adults, at 5.6% nationally and 7.4% in central Ohio. FI among older adults is concerning due to its impact on morbidity and mortality. Knowledge of associated correlates within geographic regions is limited. Prevalence of FI can vary by region, and central Ohio has one of the highest FI prevalence rates among older adults in

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the U.S. For this study, a regional cross-sectional survey with stratified random sampling was utilized to inform future development of a typology for assessing FI risk. Older adults aged 50 and above who reside in one of eight counties in central Ohio were invited to participate. The final, regionally representative sample included 1,417 older adults. Data points were weighted to accurately depict the population distribution of the region. Analysis of variance (ANOVA), correlation coefficients, and chi-square tests were utilized to examine differences between sociodemographic characteristics and food security status. We found the majority of participants who were very low food secure had the following characteristics: identified as a woman, were age 74 years or younger, were divorced, widowed, or single, earned an annual household income at or below US$39,999, had completed either some college but had not earned a degree or earned a high school diploma or GED, were either retired but not seeking work or disabled and unable to work, and lived in an urban region. Findings can inform tailored risk assessments, interventions, and referrals to community-based services and government assistance programs in central Ohio and across similar geographic regions.

Keywords
food insecurity, correlates, sociodemographic characteristics, older adults

Introduction and Literature Review

Food insecurity (FI) is an underrecognized problem among older adults. FI impacted 13.5% of households in the U.S. in 2023 (Rabbitt et al., 2024). This equated to 47.4 million individuals; of these households, 8.4% experienced low food security, and 5.1% experienced very low food security. In central Ohio, older adults experienced FI at a rate of 7.4%, which is one of the highest in the U.S.; recent federal data indicates a FI rate of 12.8%, which represents a significant increase and historic high since 2011 (Rabbitt et al., 2024), mirroring national trends. FI is further compounded by the 26.7% of older adults who report struggling to find foods they want to eat, reflecting broader challenges in food access (Flynn, 2025). Older adults living in poverty face a disproportionate burden (Leung & Wolfson, 2021). This may be attributed to multiple factors, including increased financial burden, social isolation, health limitations, and lack of access to resources. For many older adults, the financial burden of living on a fixed income impacts their ability to maintain food security. While rising food costs may exacerbate the challenges of living on a fixed income and access to nutrient-dense foods, little research has been done in the U.S. to identify demographic correlates of FI among older adults specifically.

Literature has established that older adults who are single and living alone are at increased risk of FI (Reed-Jones, 2023). Older adults living alone often face increased social isolation compared to those living with others, limiting their ability to access food retailers and other assistance programs such as the USDA's Senior Farmers Market Nutrition Program (SFMNP), Supplemental Nutrition Assistance Program (SNAP), and Produce Perks that might otherwise promote food security (Burris

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Conflict of Interest
The authors report no conflicts of interest.

Ethical Standards Disclosure
This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by The Ohio State University Institutional Review Board (IRB). Written informed consent was obtained from all subjects/patients.

Author Contributions
Lauren Roberson: Conceptualization; Methodology; Formal Analysis; Writing Original Draft; Writing—Review & Editing
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et al., 2021). Health limitations, particularly those associated with decreased mobility, also disproportionately impact older adults living alone and without a support network, as they are less physically able to seek out food resources (Aday et al., 2023).

Food insecurity is a complex, systemic concern widely recognized as a social determinant of health. A relationship between FI and sociodemographic characteristics, financial and social networks, healthcare and food access, and community-based resources has been established in previous literature (Pooler et al., 2018; Sen et al., 2025). People living in food-insecure households may also have limited dietary variability and less nutritionally dense diets (Rabbitt et al., 2024).

Our study examines sociodemographic correlates of FI among older adults (ages 50–95 years) across eight counties in central Ohio to inform the development of a typology of older adults at risk of FI in the region. By specifically examining sociodemographic characteristics such as income, geographic region of residence, and education level, we can determine whether there is a relationship between each characteristic and food security. Sociodemographic characteristics can then be incorporated into a typology to inform risk assessment. Geographic region is an especially important consideration when attempting to better understand FI for two reasons. First, food accessibility, socioeconomic status, and awareness and availability of assistance programs (e.g., SNAP), varies by region. Second, by identifying correlates within a unique region, public health practitioners and interventionists are better prepared to develop tailored approaches to screen for and help mitigate FI risk. These correlates, and eventually a typology, have significant implications for prompt screening of FI risk while also encouraging connection to social protection programs at the community level. We posed two research questions to better understand characteristics associated with very low, low, and high food security among older adults. The first examines the difference in food security status across several sociodemographic variables.

> RQ1: Does the food security among older adults in central Ohio differ (a) by gender identity, (b) age, (c) race and ethnicity, (d) marital status, (e) sexual orientation, (f) income, (g) education level, (h) employment status, (i) region of residence, (j) immigrant status, or (k) veteran status?

The second research question delves deeper by exploring the association between these sociodemographic variables and food security status.

> RQ2: Is food security status related to geographic region of residence, age, marital status, employment status, education level, and housing tenure (rent versus own) among older adults in central Ohio?

Applied Research Methods

Data for the study came from the 2021 Central Ohio Regional Assessment on Aging (CORAA). This assessment was conducted by the Age-Friendly Innovation Center, College of Social Work, the Ohio State University, in collaboration with the Central Ohio Area Agency on Aging and the Franklin County Office on Aging. The CORAA survey, conducted every five years, aims to understand social services and provide insight on key questions of older adult safety, health, and well-being in the region. The assessment surveyed older adults from the eight-county region of central Ohio using a stratified random sample across counties, resulting in regionally representative data. The sample was drawn from residential addresses most likely to have occupants over 50 years old. Participants were mailed a paper copy of the survey and asked to complete it and return via a prepaid envelope. Study protocol was approved by the Institutional Review Board (IRB) at the Ohio State University. Prospective participants were given an informed consent form to review and were provided a phone number they could call to ask questions before data collection began. By completing the survey, participants indicated their consent to participate. For the purposes of the paper, we utilized the term "older adult" to refer to all adults aged 50 years and older. While Dewey et al. (2025) classified senior individuals as those aged 60 and older, we have updated this term for our research based on recommendations for age-inclusive language (Trucil et al., 2020; Van Vleck, 2022). The

ETC Institute, a survey research firm, administered the survey via mail, with a 15% response rate. Individuals were eligible to participate if they met the following criteria: a resident of one of the eight counties, aged 50 years and above, and English-speaking. Geographic region of residence was classified according to the U.S. Census Bureau definitions of urban and rural. Urban regions are classified as having a population of 50,000 or greater, while rural regions are classified as having a population less than 2,500 (Ratcliffe et al., 2016). "Partially rural" is a term used by the Ohio Department of Aging and accounts for regions that have both urban and rural characteristics. Of the eight counties included in our study, three were urban, four were partially rural, and one was rural, as defined by the Ohio Department of Health (2020). Our sample is reflective of the following state and national characteristics: proportion of the population identifying as female, proportion of individuals aged 65 years and above, annual household income, proportion of individuals living in poverty, and number and proportion of employed individuals. See Table 1 for a comparison of key demographic data from our sample with state and national trends.

The survey data, stratified by county, were weighted to accurately reflect the region's population distribution. The final sample included 1,417 older adults. While analyses to address both RQs utilized a sample of 1,417, missing demographic data resulted in a sample size of 1,371, as reported in the appendix (Table A).

Variables

While there are notable variations in the definition of food security status and corresponding classifications, we used the definitions from the U.S. Department of Agriculture, Economic Research Service (USDA ERS, 2025): very low food security, low food security, and high food security. Food security was measured via a 1-item question, *"Over the last year, how often were you worried about not having enough food to eat?"* This single-item question was chosen because it reflects a feasible, convenient means of screening for FI, similar to the Hunger Vital Sign (HVS) tool (Hager et al., 2010). Given that our survey's purpose was to identify pressing needs of the aging demographic in this region, a single-item screener question was deemed sufficient to identify food security status so further probing could occur. Further, use of a single-item screener has been validated in the literature when compared to the USDA Household Food Security Survey Module Short-Form (HFSSM-SF; Jarvis et al., 2025). The USDA HFSSM-SF is considered the

Table 1. Comparison of Key Demographic Data from Our Sample with State and National Trends

	Central Ohio				
Characteristic	Urban	Partially Rural	Rural	Ohio	U.S.
Population	583,055	86,801	28,782	11,883,304	340,110,988
Sex (% female)	50.5	48.6	50.9	50.7	50.5
Individuals aged 65 and above (%)	16.0	16.3	18.8	19.1	18.0
Persons per household	2.6	2.6	2.5	2.4	2.5
Household income (US$)	$94,972	$88,183	$60,047	$69,680	$78,538
Poverty (%)	9.9	8.7	14.4	12.7	10.6
Number of persons employed (% of population)	289,123 (50)	25,751 (30)	9,980 (35)	5,081,279 (43)	139,831,742 (41)
High school graduation or higher (%)	93.8	91.6	85.8	91.6	89.4
Bachelor's degree (%)	43.1	28.7	13.8	30.9	35.0
Disability status *(%)*	8.5	9.5	14	10.2	9.1

gold standard measure of food security status. Response options for our 1-item measure included always, frequently, sometimes, rarely, and never. Responses of *always* and *frequently* were coded as very low food security, while responses of *sometimes* were coded as low food security. Responses of *rarely* and *never* were coded as high food security. While response options deviated from the gold standard six-item HFSSM-SF measure, we used the same terminology to classify food security status. The USDA ERS (2026) has defined very low food security as "reports of multiple indications of disrupted eating patterns and reduced food intake" (para. 5). Low food security is defined as "reports of reduced quality, variety, or desirability of diet. Little or no indication of reduced food intake" (para. 4). High food security is defined as either "no reported indication of food-access problems or limitations" (para. 2) or "one or two reported indications—typically of anxiety over food sufficiency or shortage of food in the house. There is little or no indication of changes in diets or food intake" (para. 3).

Sociodemographic variables included gender identity (man, woman, trans man or trans woman, nonbinary, and other); race and ethnicity (Asian/Pacific Islander, Black/African American, Native American, white/Caucasian, Hispanic/Latino, prefer not to answer, and other); marital status (single, married, divorced, or widowed); education level (high school diploma or GED, some college but no degree, associate's degree, bachelor's degree, and graduate or professional degree); and sexual orientation (heterosexual, gay, lesbian, bisexual, other, and prefer not to answer).

Participants also selected the county where they resided, provided the year they were born, and responded to dichotomous questions about their immigration and veteran status. Participants selected from various types of employment status (employed full-time, employed part-time, self-employed, unemployed but seeking work, enrolled in a work training program, retired and not seeking work, and disabled and unable to work). Housing tenure was measured by asking participants whether they owned or rented their home and if they had a mortgage.

Household income was measured by the question, *"What was your household income last year?"* Response options included under US$10,000; US$10,000–24,999; US$25,000–39,999; US$40,000–59,999; US$60,000–74,999; US$75,000–99,999; US$100,000 or more; and prefer not to answer.

Data Analysis

To address RQ1, a one-way analysis of variance (ANOVA) was conducted to compare differences in food security status across sociodemographic variables. Bonferroni post-hoc tests were conducted to determine which specific sociodemographic variables differed significantly by food security status. To address RQ2, Pearson product-moment correlation coefficients were computed to assess the relationship between food security status and sociodemographic variables, including socioeconomic status (education, geographic region of residence, and income), age, marital status, gender identity, and housing tenure (rent versus own). Moreover, chi-square tests were utilized to determine differences in food security status by sociodemographic variables. SPSS version 29.0.1.0 was used to perform all analyses.

Results

The purpose of this study was to identify sociodemographic correlates of food security status among older adults in central Ohio to inform future development of a typology of FI risk. Results from RQ1 outline how food security status *differs* by sociodemographic factors, including urban versus rural county of residence, age, gender identity, race and ethnicity, immigration status, veteran status, marital status, employment status, and education level. Results from RQ2 examine whether food security status is *related* to socioeconomic status, other sociodemographic factors mentioned above, and housing tenure and whether those relationships *differ* by food security status.

Participant Demographics

Most participants in the sample (N = 1,417) were white (83.6%), English-speaking (96.9%), and married (63.6%). Further, most participants identified as women (56.3%), identified as heterosexual (97.3%), and were retired and not seeking work

(53.1%) at the time of data collection. Just under 97% of participants had complete data for all variables of interest (N = 1,371). Of the entire sample, 7% were food insecure (5% were low food secure and 2% were very low food secure). Ninety-three percent of participants were highly food secure. According to the 1-item measure, mean food security among the sample was 4.7 ($SD \pm 0.7$) on a 5-point scale, indicating that participants trended toward being food secure.

Very low food security

Of participants experiencing very low food security, common characteristics included identifying as a woman (66.2%), 60–64 years of age (25.9%) followed closely by 50–59 years of age and 65–69 years of age (each 22.2%) and 70–74 years of age (18.5%), identifying as white (66.7%), divorced (35.7%), followed closely by widowed (32.1%), identifying as heterosexual (100%), earning an annual household income under US$10,000 (45.8%) followed closely by earning an annual household income between US$10,000 and $24,999 (37.5%), having taken some college courses but not earning a degree (28.6%), followed closely by having a high school diploma or general equivalency diploma (GED; 25%), retired and not seeking work or disabled and unable to work (each 40.7%), residing in an urban region (59.5%), nonveteran status (100%), and nonimmigrant status (92.9%).

From our data, it appears that characteristics such as identifying as male, age 75 years or greater, married, earning an annual household income above US$24,999, earning at least a high school diploma or GED, and part-time, full-time, self-employment, unemployment, or enrollment in a work training program are protective against very low or low food security. From a geographic standpoint, residing in a rural or partially rural region also appears to be protective.

Low food security

Of those experiencing low food security, the most common characteristics included identifying as a woman (66.2%), 65–69 years of age or 75–80 years of age (each 25%), identifying as white (80.6%), divorced (38.6%), and identifying as heterosexual (97.1%). Economically, low food security status was highest among participants with annual household incomes less than US$39,999 (83%), having completed some college but earned no degree (38.6%), and those who are retired and not seeking work (52.9%) or those who are disabled and unable to work (26.5%). Further, those living in an urban region also had higher rates of low food security status (82.4%). Veteran status did not appear to impact food security among the majority of participants (7.1%), while 100% of immigrants did not experience low food security. Low food security rates by age are variable, so no age range appears to be protective in this context. Similar results were found with marital status. Earning an annual household income greater than or equal to US$40,000 appears to be protective against FI.

High food security

Of those experiencing high food security, the most common characteristics included being married (60.2%), earning an annual household income greater than or equal to US$40,000, with a slight advantage for those earning a bachelor's or graduate/professional degree (26.5% and 23.2%, respectively). There are some nuances between characteristics of participants qualifying as very low and low food security status. While being retired and not seeking work was associated with increased risk of low or very low food security, the opposite was true for high food security. Rather, 53.1% of participants reporting they were retired and not seeking work were highly food secure. Similarly, while residing in an urban region was associated with very low or low food security status, this was not the case for those with high food security status (i.e., 71.6% of participants residing in an urban region were food secure compared to 23.1% residing in a partially rural region and 5.3% residing in a rural region). Interestingly, participants identifying as a man or woman had similar rates of high food security (44.1% and 55.6%, respectively), indicating region of residence alone may not be enough to include in a future risk assessment. Furthermore, food security rates varied by age, indicating, too, that this may not be the most reliable characteristic for assessing risk. Other variables, beyond what was measured here, should also be considered. See

Table A in the Appendix for a breakdown of participant sociodemographic characteristics by food security status (e.g., very low food security, low food security, and high food security).

In response to RQ2, there were some notable household demographic and regional differences in food security status (i.e., very low food security vs. low food security vs. high food security) across several variables, including geographic region of residence, age, marital status, employment status, and education level. Regionally, food security status across three of the eight participating counties was significantly different, $F(2, 1{,}385) = 4.27$, $p = .014$. Specifically, food security status was higher in one urban county ($M = 4.5$, $SD \pm 0.9$) but lowest in another ($M = 4.7$, $SD \pm 0.6$).

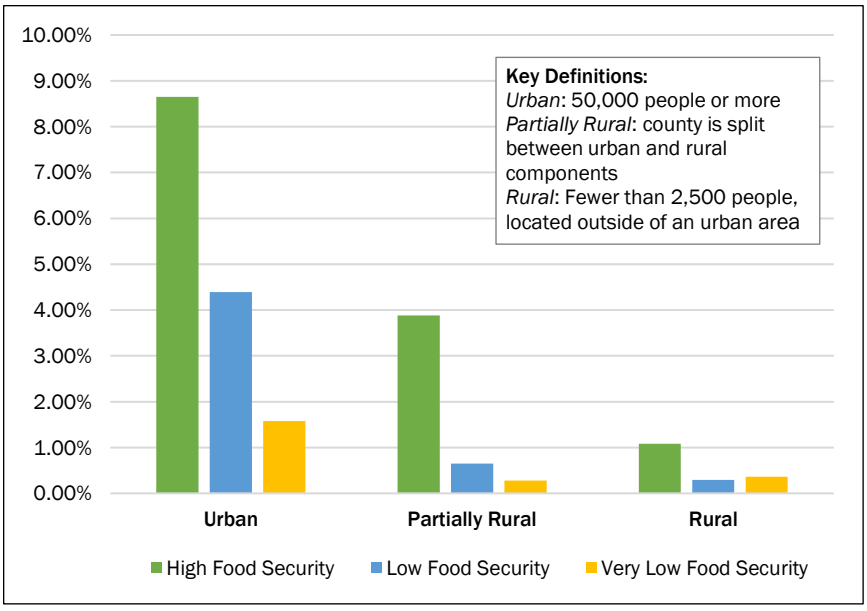
Differences between urban and rural counties were statistically significant, with older adults in one rural county ($M = 4.7$, $SD \pm 0.7$) experiencing higher food security status than those in two of the three urban counties. Our data revealed that, to an extent, older adults residing in urban counties experienced either very low or low food security relative to those residing in partially rural and rural regions.

For context, the urban county with the lowest food security status is home to the state capital and largest city. The population is 1,323,807, with 13.5% aged 65 years and older and with a median household income of US$73,795. On the contrary, the urban county with the highest food security status has a population of 214,124, with 15.5% aged 65 years and older, and a median household income of US$130,088. The third urban county has a population of 184,898, with 18.2% aged 65 and over and with a median household income of US$81,033. On average, partially rural counties have a population of 86,793 (ranging from 62,158 to 167,762), with 16.3% aged 65 and over (range 13.6–17.4%), and a median household income of US$88,183 (range US$72,927–109,506). The rural county in our sample has a population of 158,921, with 16.9% of the population aged 65 years and older, and a median household income of US$87,069. All data were retrieved from the July 1, 2024, U.S. Census Bureau Population Estimates (U.S. Census Bureau, 2024). Figure 1 provides a geographic breakdown of food security status, revealing that the urban counties had varying degrees, with some high and some low compared to the other counties.

Food security status varied by age, $F(5, 1{,}326) = 2.59$, $p = .024$. Very low food security was highest among those aged 60 to 64 years who were nearing retirement ($M = 4.6$, $SD \pm 0.8$), while older adults aged 80 years and above who had been retired for some time experienced higher food security ($M = 4.9$, $SD \pm 0.5$). Figure 2 presents the distribution of food security status across age groups, showing that high food security increases with age, to an extent. This appears to be true up until age 74. At age 75 and above, individuals trended toward being less food secure. On the other hand, individuals near or at retirement (ages 50–69) appear to be at increased risk of very low food security.

Marital status appeared to be protective against very low or low food security in

Figure 1. Region and Food Security Status



our sample, F(3, 1,347) = 41.65, p = <.001. Divorced (M = 4.4, SD ± 0.9), single (M = 4.5, SD ± 0.9), and widowed (M = 4.6, SD ± 0.8) participants experienced very low and low food security. Married individuals (M = 4.9, SD ± 0.4) were significantly more food secure than single persons, F(3, 1,347) = 41.65, p = <.001. Figure 3 illustrates differences in food security status by marital status, indicating that married individuals may be protected against very low and low food security to an extent, whereas divorced individuals and those living in single-person households experienced very low and low food security to greater extents.

Participants with less stable employment or income consistently demonstrated very low and low food security status, F(12, 1,375) = 14.39, p = <.001. Individuals with disabilities who were unable to work experienced the very low food security status (M = 3.9, SD ± 1.3), followed by retired individuals not seeking work (M = 4.3, SD ± 1.1). Those enrolled in a work training program (M = 5.0, SD ± 0.0), employed part-time (M = 4.9, SD ± 0.3), or employed full-time (M = 4.8, SD ± 0.5), experienced higher food security status.

Figure 2. Age and Food Security Status

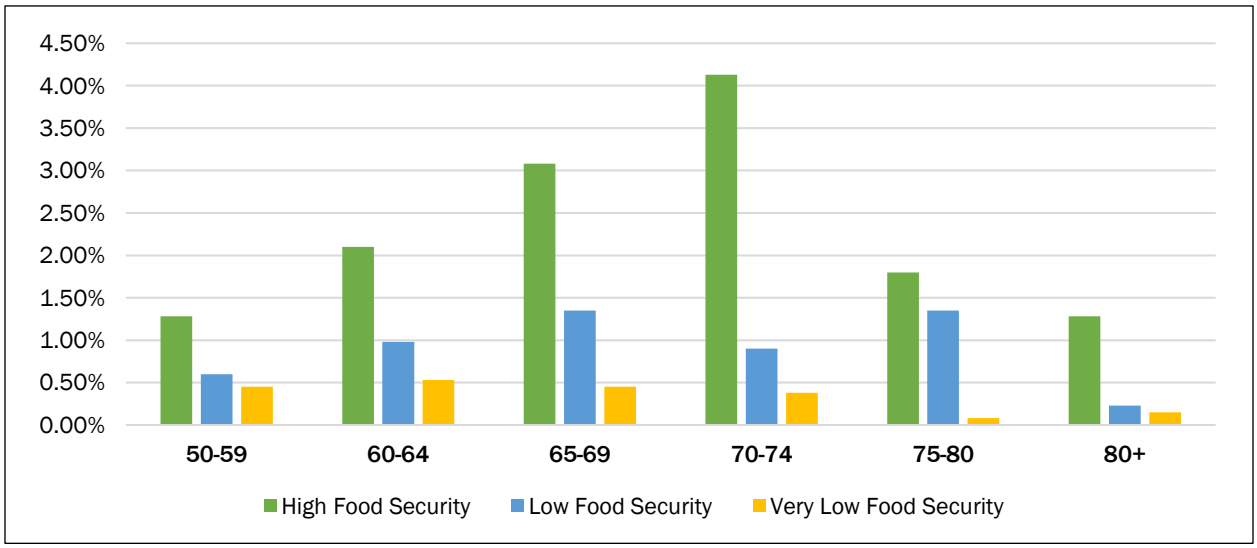


Figure 3. Marital Status and Food Security Status

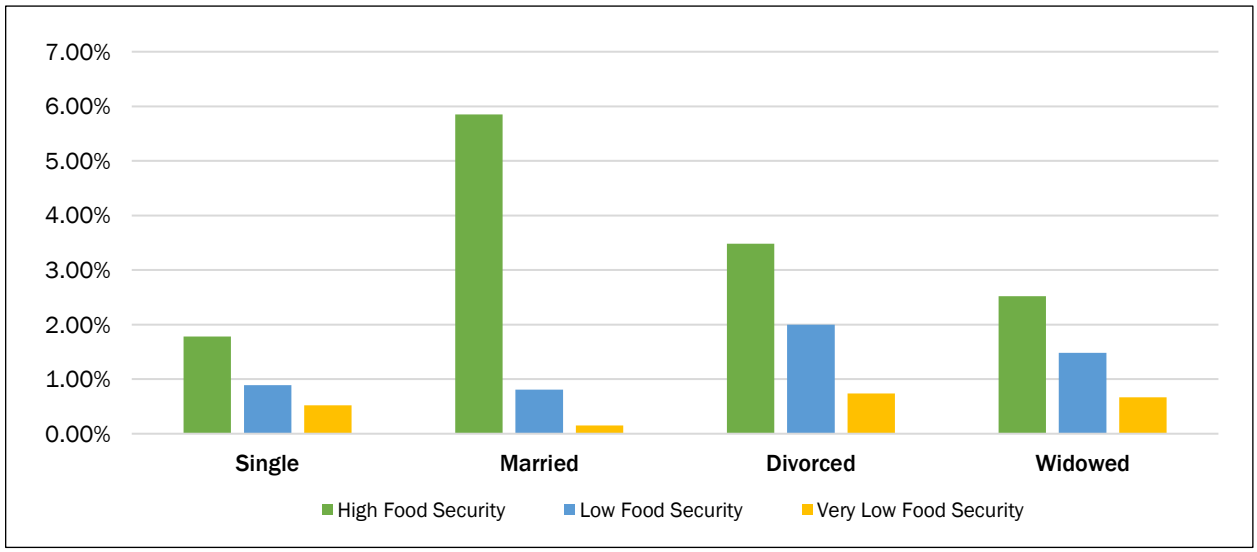


Figure 4 relates employment status to food security status, with employed individuals exhibiting the highest food security.

Furthermore, while education level also significantly influenced food security status, $F(5, 1{,}349) = 8.5$, $p = <.001$, the mean differences, according to our measure, were negligible, as explained below and in Table 2. Those with some college but no degree ($M = 4.5$, $SD \pm 0.8$), a high school diploma or GED ($M = 4.6$, $SD \pm 0.8$), an associate's degree ($M = 4.7$, $SD \pm 0.7$), and no high school diploma or GED ($M = 4.7$, $SD \pm 0.8$) had very low or low food security in our sample. On the other hand, participants with a bachelor's ($M = 4.8$, $SD \pm 0.5$) or graduate or professional degree ($M = 4.8$, $SD \pm 0.5$) were highly food secure. While differences in food security were only statistically significant for those with a bachelor's and graduate or professional degree, findings indicate that, to an extent, education may protect food security. Refer to Table 2 for means and standard deviations of food security status by education level.

Table 2. Mean Food Security Status by Education Level

Education Level	Mean [a]	Standard Deviation
Graduate or professional degree	4.8	0.5
Bachelor's degree	4.8	0.5
Associate's degree	4.7	0.7
Some college, no degree	4.5	0.8
High school diploma or GED	4.6	0.8
No high school diploma	4.7	0.8

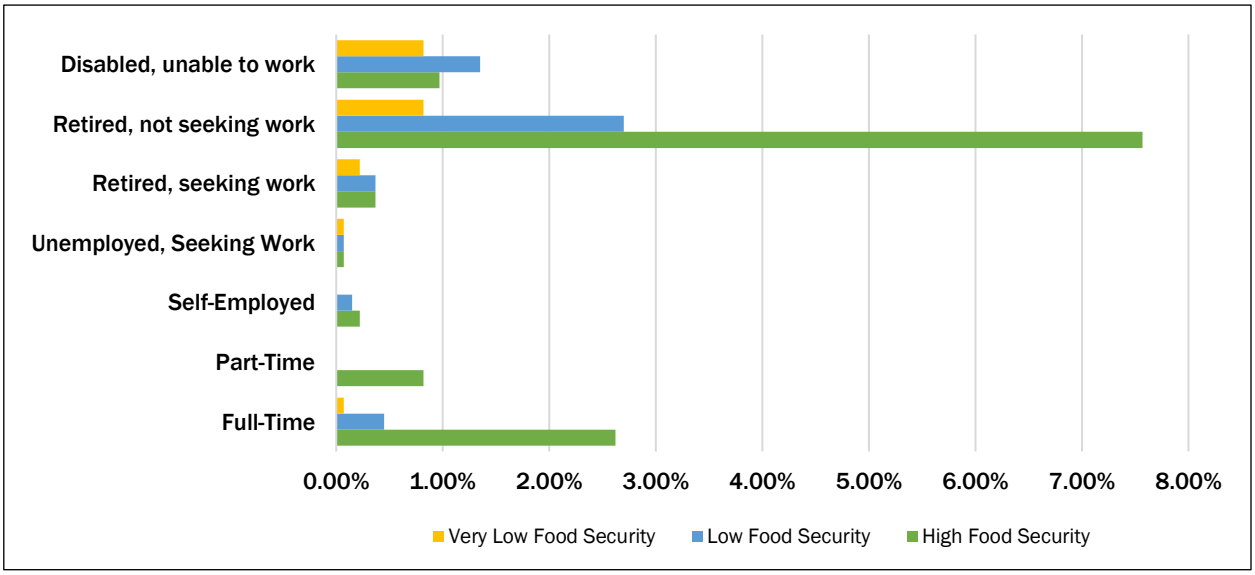
[a] FI risk was rated on a 5-point Likert scale with 1 = *very low food security* and 5 = *high food security*.

As shown in Figure 5, food security status was associated with more formal education resulting in a degree; however, some formal education does not appear to be associated with food security status.

Immigration status or veteran status do not appear to influence food security status. However, our sample is likely not diverse enough to capture these nuances, as was the case with race and ethnicity and sexual orientation.

In response to RQ2, there was a weak positive correlation between household income and food security status, $r(1{,}115) = .36$, $p = <.001$. Participants with lower household income experienced very low or low food security. Chi-square analyses were statistically significant, X^2 $(1, N = 24) = 192.23$, $p < .001$, revealing those earning under US$10,000 annually and those earning between US$10,000 and US$24,999 annually experienced very low food security (45.8% and 37.5%, respectively).

Figure 4. Employment Status and Food Security Status



Correlations between age, $r(1,331) = .07$, $p = .008$, education level, $r(1,354) = .15$, $p = <.001$, marital status, $r(1,350) = -.12$, $p = <.001$, housing tenure (rent versus own), $r(1,355) = -.14$, $p = <.001$, and food security status were statistically significant, but negligible. Correlation between gender identity, $r(1,371) = -.05$, $p = .060$, sexual orientation, $r(1,330) = .01$, $p = .642$, and food security status was not statistically significant.

Discussion

With this study, we sought to identify key correlates of food security status among older adults in central Ohio using a regional sample. Findings suggest some characteristics that may be common among individuals experiencing very low or low food security. This work serves as the first step in an attempt to recognize very low or low food secure individuals early so they can be enrolled in food assistance programs. We discuss the implications of these findings next.

Toward a Typology of the Food-Insecure Older Adult

We found very low and low food security status among individuals (a) identifying as a woman, (b) age 74 years and younger, (c) divorced, widowed, or single, (d) earning an annual household income at or below US$39,999, (e) those with either some college but no degree or those with a high school diploma or GED, (f) those who were either retired but not seeking work or disabled and unable to work, and (g) living in an urban region. See Figure 6 for proposed characteristics to be included in future development of a typology to inform screening for very low and low food security status.

Higher education levels, such as earning a bachelor's degree or a graduate or professional degree, appeared protective against very low and low food security status, consistent with prior literature. National trends suggest very low and low food security status is higher in rural areas, but our findings align with Gundersen et al. (2017)'s observation that people in urban-adjacent areas experience very low and low food security to a larger extent. While very low and low food security status generally declines with age, there are several reasons why food security status may have been lower among the 50–74 age group in our sample. Many older adults are not aware of available aging services or are unaware of the eligibility criteria (Bolkan et al., 2022; Denton et al., 2008). Of concern, many chronic diseases manifest and are diagnosed in this age range, contributing to food security status. For example, researchers found the mean age of chronic disease onset to be 62 years in their longitudinal analysis (Stacherl & Sauzet, 2024). From a financial lens, individuals age 64

Figure 5. Education Level and Food Security Status

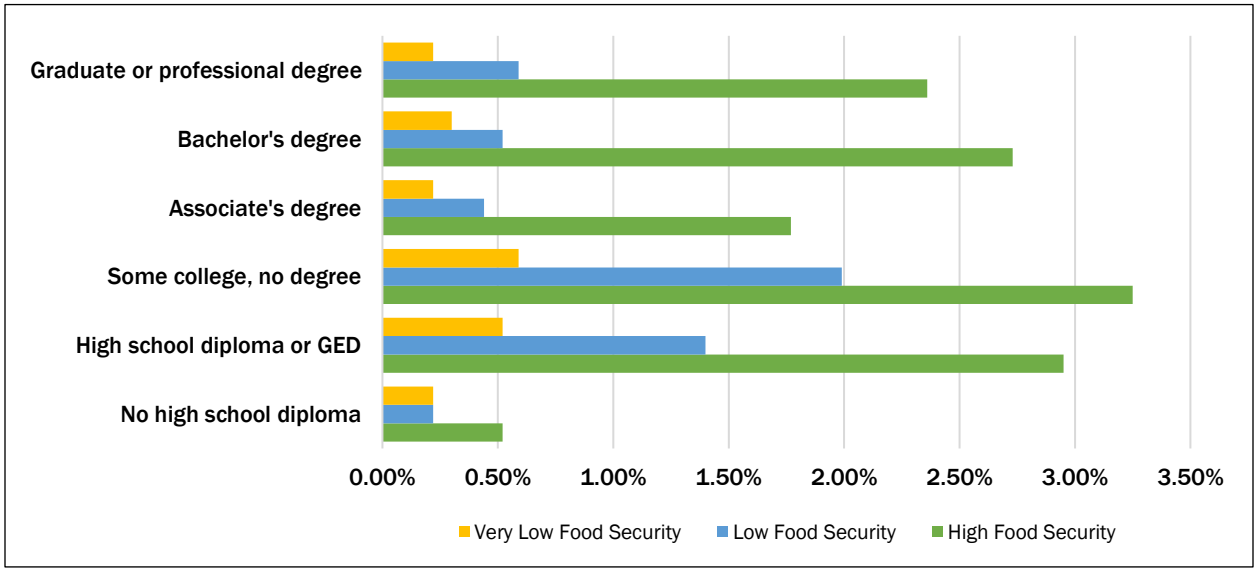
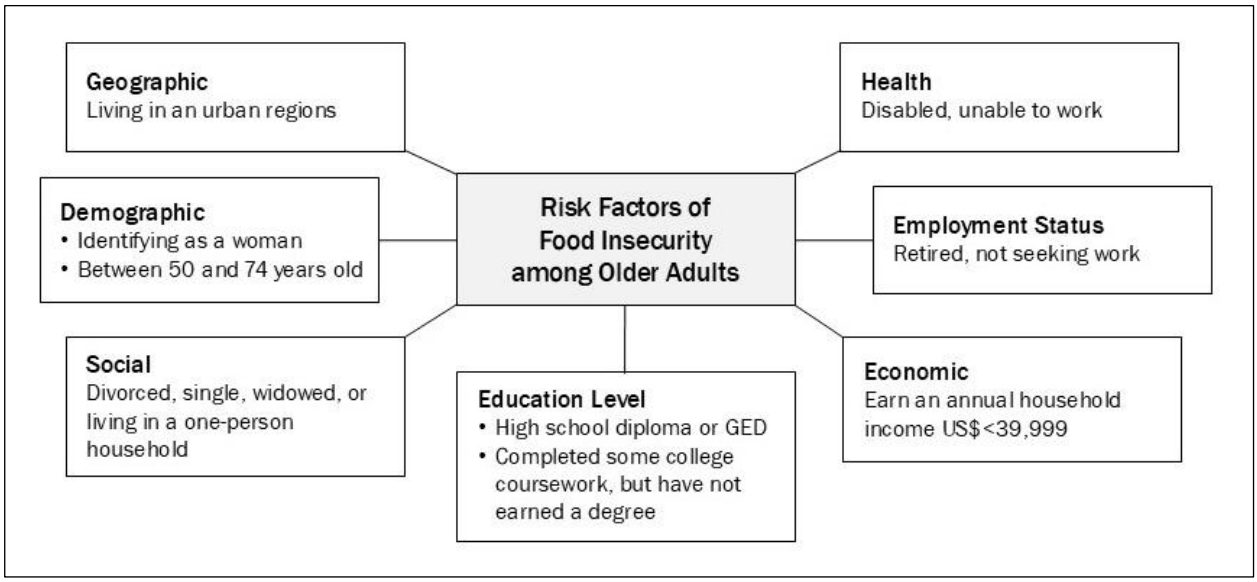


Figure 6. Factors Associated with Food Security Status Among Older Adults



years and under often face unique challenges as many are preparing for retirement (Brown et al., 2019). Factors such as increased medical expenses, debt, and lower investment returns highlight the need for targeted financial literacy and retirement-planning interventions. Likewise, living in a single-person household may impact food security status due to economic and social factors (Burris et al., 2021; Tamborini, 2007). These challenges create a pressing need for additional policy support to reduce healthcare expenditures and optimize return on investment, all of which could benefit older adults as they enter retirement.

Disabilities significantly contribute to food security status through functional limitations, increased healthcare costs, and restricted food access (Jones, n.d.; Kim et al., 2009). Very low or low food security status can impede mobility, creating a vicious cycle of poor health and diminished independence (Bishop & Wang, 2018). Regional public health interventions must therefore address multiple intersecting factors to mitigate the compounded effects of very low or low food security among older adults and individuals with disability, including access to affordable transportation (Dabelko-Schoeny et al., 2021).

Federal and state-level nutrition incentive programs can help older adults optimize their limited income to access healthy, affordable food. The Gus Schumacher Nutrition Incentive Program (GusNIP-NI) and Produce Prescription Programs (GusNIP-PPR) provide funding for programs that incentivize the purchase of fresh produce for eligible households to improve dietary intake and food security status, while also reducing healthcare needs and costs (USDA National Institute of Food and Agriculture, 2025). Additional programs like Produce Perks Midwest can help older adults with SNAP benefits stretch food dollars by doubling the value of SNAP at farmers markets and food retailers (Produce Perks, 2025). The USDA's SFMNP, administered by the Ohio Department of Aging, also provides low-income older adults with financial resources to purchase food through roadside stands, community supported agriculture (CSA) programs, and farmers markets (Pence, 2022). These programs help provide support for both producers and consumers, while contributing to improved local economies, thereby supporting efforts to address very low and low food security among older adults at a macro level (Bolen & Wolkomir, 2020). With the recent passage of the federal One, Big, Beautiful Bill Act, the cost of SNAP benefits will be shifted to states, while administrative costs will be transferred to counties (National Association of Counties, 2025). This shift has noticeable impact, as the Congressional Budget Office estimates that these administrative

changes will reduce SNAP funding by $187 billion, or by about 20% through 2034 (Center on Budget and Policy Priorities, 2025). By restricting the funding and accessibility for federal and state-level nutrition incentive programs, older adults in particular will face additional challenges that prevent them from maximizing their limited income to access healthy, affordable food. In addition, the cessation of the SNAP-Ed program, designed to educate individuals with limited resources on healthy food options that could be purchased and prepared on a fixed income, limits opportunities for nutrition education among vulnerable populations. Since its inception in 1977 with the Food Stamp Act, SNAP-Ed has decreased very low and low food security rates. The program has demonstrated a direct impact on dietary intake and diet quality, including increased fruit and vegetable intake and decreased intake of fast foods (Adedokun et al., 2021; Bhargava et al., 2024; Molitor et al., 2015; Rivera et al., 2018, 2019; USDA FNS, n.d.).

Limitations

This study is not without limitations. Notably, only 2% of our sample experienced very low food security, limiting the number of food-insecure individuals across sociodemographic characteristics. Also, we used a single-item measure of food security status. Other measures used in the literature range from 4 to 18 items ($M = 10.2$) according to Marques and colleagues (2014). These scales include the Modified Community Childhood Hunger Identification Project (CCHIP; Weinreb et al., 2002), Household Food Insecurity Access Scale (HFIAS; Swindale & Bilinsky, 2006), Food Insecurity by Elders (FIE; Wolfe et al., 2003), Core Food Security Measurement/Household Food Security Survey Module (CFSM/HFSSM; Bickel et al., 2000), and HFSSM-6SF and its modified version (Blumberg et al., 1999; Carmichael et al., 2007). Other scales include Tool to Assess Past Food Insecurity (Kuyper et al., 2006), Food Insecurity Questions of the National Health and Nutrition Examination Survey (NHANES III; Briefel & Woteki, 1992), Modified Food Insecurity Questions of NHANES III (Chávez et al., 2007), Radimer/Cornell Scale (R/CS; Radimer et al., 1990), Modified Radimer/Cornell Scale (R/CSm_a&d; Gollub & Weddle, 2004; Kendall et al., 1995), and Self-Administered Food Security Survey Module for Children Aged 12 and Older (SAFSSM; Connell et al., 2004). Use of a single-item measure that is based on perception of worry related to food access can underestimate actual food security status (Keenan et al., 2001; McKechnie et al., 2018; Nolan et al., 2006). Given these limitations, future work is necessary to go beyond screening to capture actual food security status across a number of dimensions among this demographic.

Our sample represents a small subset of older adults in central Ohio and is therefore not representative of state or national-level food security status among older adults. Likewise, our sample was relatively homogenous regarding race and ethnicity (81% of participants identified as white), sexual orientation (100% of participants identified as heterosexual), immigrant status (92.9% of participants reported non-immigrant status), and veteran status (100% of participants reported they were not a veteran). This limits generalizability of our findings to racial and ethnic minority groups, the LGBTQIA+ community, immigrants, and veterans. Likewise, there was a higher response rate among those living in more urban, higher-income counties. As a result, some of the most vulnerable older adults (those who are cognitively impaired, or those living in institutionalized settings) may not have been included in our sample, thus skewing the results and how reflective they are of the population of older adults in central Ohio. The cross-sectional nature of the data limits our ability to infer factors that predict or cause very low or low food security status (Goldberg & Mawn, 2015; Salazar et al., 2006).

Lastly, we cannot rule out potential self-report bias in survey responses, meaning food security status may be misrepresented among some sociodemographic groups. For example, other studies have found that middle-aged individuals aged 35–64 are more likely to report very low or low food security status when compared with other age groups (for example, Walker et al., 2021). As a result of these limitations, primarily the regional nature of these data and the use of a single-item measure, findings should be interpreted within this context.

Conclusions

These findings can, and should, raise public awareness about food security status as experienced by older adults. There are many steps that federal, state, and local aging services, in addition to nonprofits and other public health programs, can take, collectively, to increase the food security status of older adults and help make nutritious foods accessible for all.

Practical Implications

The proportion of older adults experiencing very low or low food security has continued to climb for several consecutive years following the end of additional aid during the COVID-19 pandemic and is predicted to continue increasing with the 2025 federal One, Big, Beautiful Bill Act and cessation of SNAP-Ed (Center on Budget and Policy Priorities, 2025). One in 10, or 12.6 million, adults aged 50 years and older in the U.S. experienced some degree of very low or low food security in 2023 (Dean & Figueiredo, 2025). We propose three strategies to increase food security in our region and across the greater Midwest.

Expand awareness of available resources via care navigation support

Many older adults do not know the services they qualify for and that are available to them (Denton et al., 2008). It is essential for practitioners working with older adults, especially those who are entering retirement or are approaching the eligibility age (e.g., 65 for Medicare), to provide education on eligibility and available programs in their respective region. Practitioners should help with program enrollment. Needs vary by region due to a number of factors, including food accessibility, availability of aid programs (e.g., SFMNP), and socioeconomic status. County or region-targeted education on food insecurity and associated risk factors is warranted. Financial and informational strategies should be developed for those who are at greatest risk. From a financial perspective, individuals entering retirement age (55 to 65) or going through a separation or divorce later in life could benefit from targeted financial management education that supports access to a healthy, well-balanced diet on a fixed income. One concrete example linking finances to food access and nutrition would be nutrition education on planning meals and budgeting for a single-person household. We suggest financial preparation education for retirement planning, extending beyond just 10 years prior. Financial literacy early in one's career is necessary to make wise financial decisions across the life course and secure an investment that can support retirement and unanticipated life events.

From an informational standpoint, care navigation is essential. Briefly, care navigation is a systematic means of coordinating care strategies with needed services and supports. It is often individually tailored in a case management setting by a trained professional (Pang et al., 2025). A care navigator, such as a social worker, community health worker, or senior center representative, could provide such information and assist with enrollment. New federal legislation, such as the One, Big, Beautiful Bill Act, has changed the application and recertification processes for SNAP. To address these changes, care navigators and SNAP employees can be available to help eligible individuals through the process with ease and confidence. Furthermore, care navigators can be trained to guide participants in selecting Medicare plans that specifically support meal services, limit out-of-pocket expenses, and reduce financial hardship (Park & Berkowitz, 2024).

Strengthen screening and identification of very low and low food security status

A typology or categorization of individuals experiencing very low or low food security, or those most likely to, should be tested and validated among a representative sample of older adults. When considering individuals that fit this profile, community health workers, case managers, and healthcare professionals could ask a simple screening question such as *"Have there been times in the past 12 months when you did not have enough money to buy food you or your family needed?"* (Food Research and Action Center, 2025). An evidence-based risk assessment would enable these individuals to a) screen older adults for risk and, if risk is identified, b) pair them with necessary resources to mitigate that risk (Goldberg & Mawn, 2015). For example, community-based organizations could be educated

on the risk factors we identified (i.e., identifying as a woman, age 74 years or younger, divorced, widowed, or single, earning an annual household income at or below US$39,999, those with either some college but no degree or those with a high school diploma or GED, those who were either retired but not seeking work or disabled and unable to work, and living in an urban region). From there, individuals matching one or more of these risk factors could then be screened using the one-item measure we suggest. If the individual scores at risk, trained professionals could then administer a more detailed assessment to inform necessary referrals for additional services and aid programs. Such screenings or assessments should be mandated as part of intake paperwork for utilization of healthcare services or enrollment in community-based assistance programs, with follow-up every six months to catch needs early.

Protect and prioritize existing social safety net programs

At present, there are three federal programs that should be bolstered: social security benefits, federal nutrition programs (e.g., SNAP, SFMNP, Produce Prescriptions), and the Older Americans Act (OAA). Suggestions for each are discussed below. Social security benefits should be protected and prioritized, even among early entitlement age, as research has shown this program can decrease the prevalence of FI, even during periods of economic turmoil (e.g., the recession, COVID-19; Singleton, 2023). If these protective services go away, then the U.S. will face increased healthcare expenditures for the physical and mental health conditions that are established consequences of FI in addition to poorer health outcomes, decreased lifespan, and quality of life.

From a policy standpoint, while the Agriculture Improvement Act of 2018 (commonly referred to as the farm bill) was composed of several place-based food policy councils working to address community needs, the bill expired on September 30, 2025. Continued advocacy and sup-port of this bill is essential in improving food security among older adults. Equally as important are programs such as SNAP, SNAP-Ed, SFMNP, and Produce Prescription, which have been shown to be effective at mitigating FI among older adults. Such programs should also be prioritized in advocacy and policy work (Aljahdali et al., 2024; Hager et al., 2023; O'Dare Wilson, 2017; Schanzenbach, 2023). Research has shown that older adults underutilize SNAP benefits (Berkowitz, et al., 2017; Berkowitz et al., 2021; Giordono et al., 2022). A targeted campaign to increase utilization of such social protection programs should therefore be prioritized.

In addition to the farm bill, advocacy for the reauthorization of the OAA, calling for a redistribution of funding to more congregate and home-delivered meal programs and nutrition education is warranted. The reauthorization should mandate that OAA programs have a food security navigator, or someone (a case manager, for example) who is trained to assess and connect older adults with food-related resources. At the federal level, the OAA Reauthorization that passed in the Senate included enhanced nutrition services to further support the needs of this population. At the time of writing, this reauthorization is being considered in the House (Freed et al., 2025; USAging, 2025). Advocacy and support for OAA reauthorization is timely and vital for influencing policymakers during this legislative session.

Leverage existing state and local infrastructure

To give some context about the geographic region where this data was collected, several counties in central Ohio have a property tax levy in place that fund services for older adults specifically (The Center for Community Solutions, 2018). While services vary from county to county, examples of programming include nutrition, transportation, home modification, case management, caregiver support, disease management, and health promotion (Freed et al., 2025). In addition to advocacy for legislation at the federal level, state plans are an excellent way to specify goals related to food security status. From a financial perspective, local coalitions could push for county levies to support senior centers and other service infrastructure, as these have great potential to promote high food security among the clients they serve. State units on aging are required to formulate state plans every five years. Incorporating one or more goals targeting food security has

merit and can contribute to actionable change by mobilizing units like the Area Agencies on Aging, which can implement much-needed programming. There is value in this programming being prioritized by and within the aging network. By focusing on regional relationships outside the traditional networks, each state could utilize and consolidate resources that advocate for food and nutrition support.

Directions for Future Research

By studying the social determinants of health that directly impact FI risk (e.g., sociodemographic characteristics, housing, food access), we can better develop a tailored solution that combines education, advocacy, and systems-level change. By addressing the gap in FI literature among the population of older adults in the Midwest, our research suggests two strategies to consider.

Develop and implement interventions targeting financial and nutritional determinants

Financial literacy education curricula should be developed, pilot-tested, implemented, and evaluated, targeting populations at greatest risk of FI (i.e., identifying as a woman, age 74 years or younger, divorced, widowed, or single, earning an annual household income at or below US$39,999, those with either some college but no degree or those with a high school diploma or GED, those who were either retired but not seeking work or disabled and unable to work, and living in an urban region). While a financial literacy model is controversial among some disciplines, financial education may be a viable starting point. However, as the social determinants of health theory posits, there are many factors that increase risk. Rather than focusing on the individual, it is necessary to address community-level barriers to food security, such as transportation and food access, to create systems-level change. Evidence-based nutrition education, such as the curriculum provided by SNAP-Ed and the Expanded Food and Nutrition Education Program, can help at-risk individuals learn food resource management skills while navigating federal food and nutrition assistance programs. Prior research has emphasized the underutilization of programs like SNAP; warranting future research to better understand barriers to participation (Berkowitz et al., 2017; Berkowitz et al., 2021; National Council on Aging, 2025; Schanzenbach, 2023). Pre- and post-measures of food security status should be collected at multiple timepoints to determine efficacy and effectiveness. In addition, future research may collect self-reported objective measures of nutrition status (food frequency questionnaire, 24-hour recall, food diary) and biological measures of nutrition status (skin carotenoids, body composition, blood samples, etc.).

Utilize a mixed methods approach to better understand the experiences of at-risk older adults

A qualitative exploration is necessary to further contextualize findings from the perspective of those with lived experience. For example, older adults who are food insecure and qualify for services but do not use them would be an important population to reach. Findings would help public health practitioners and interventionists better understand challenges and barriers to identifying services, enabling them to devise best practices for overcoming those challenges (Goldberg & Mawn, 2015). While survey data provides documentation of issues and a profile of those who are at highest risk, qualitative data can provide a more in-depth understanding of how participants experience FI and can reveal challenges and barriers that restrict access to utilizing assistance programs. For each of these strategies, sample stratification is necessary to ensure equitable diversity across demographic variables, especially income, race and ethnicity, and sexual orientation. Targeted recruitment in areas known to be food deserts and regions with very low and low food security status among older adults is recommended. Moreover, racial and ethnic minority groups, the LGBTQIA+ community, immigrants, and veterans should be intentionally recruited in future studies. To better understand the lived experiences of these minority groups, qualitative explorations are warranted to provide nuance of their food-related experiences as older adults.

With recent changes to federal legislation, coupled with the rise in the aging demographic across the U.S., it is imperative to address FI. If left unaddressed, FI can result in increased risk of chronic disease, morbidity, and mortality, all of

which can increase healthcare expenditures and healthcare burden, which is already strained (Berkowitz et al., 2018). By centering on region-specific patterns and determinants of food security status, our study employs a targeted and context-sensitive approach that enhances our ability to identify sociodemographic characteristics to support the development of effective, locally relevant interventions. Our attempt to categorize sociodemographic characteristics to inform the development of a typology of food-insecure older adults has merit and potential to serve as a front-line screening tool by trained professionals who work with older adults regularly. Given that certain sociodemographic characteristics such as identifying as a woman, age 74 years or younger divorced, widowed, or single, earning an annual household income at or below US$39,999, those with either some college but no degree or those with a high school diploma or GED, those who were either retired but not seeking work or disabled and unable to work, and living in an urban region are all related to food security status, future intervention and policy decisions should prioritize individuals that match these characteristics. Tailored interventions, risk assessments, and referral to existing community-based services and infra-structure are cost-effective ways to address this pressing issue.

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Appendix

Table A. Participant Characteristics by Food Security Status

	All Survey Participants		High Food Security		Low Food Security		Very Low Food Security	
Gender Identity	*n* = 1,371		*n* = 1,271		*n* = 71		*n* = 29	
	Yes	%	Yes	%	Yes	%	Yes	%
Man	596	43.5	561	44.1	24	33.8	11	37.9
Woman	772	56.3	707	55.6	47	66.2	18	66.2
Trans man or trans woman	2	0.1	2	0.2	0	0.0	0	0.0
Nonbinary	1	0.1	1	0.1	0	0.0	0	0.0
Mean Age (Years)**	*n* = 1,332		*n* = 1,233		*n* = 72		*n* = 27	
50–59	161	12.1	147	11.9	8	11.1	6	22.2
60–64	194	14.6	174	14.1	13	18.1	7	25.9
65–69	300	22.5	276	22.4	18	25	6	22.2
70–74	285	21.4	268	21.7	12	16.7	5	18.5
75–80	204	15.3	185	15	18	25	1	3.7
80 and above	188	14.1	183	14.8	3	4.2	2	7.4
Race and Ethnicity	*n* = 1,358		*n* = 1,256		*n* = 72		*n* = 30	
Asian	30	2.3	27	2.1	2	2.8	2	6.7
Black	145	10.7	129	10.2	9	12.5	7	23.3
White	1,135	83.6	1,057	84.2	58	80.6	20	66.7
Latino	37	2.7	34	2.7	2	2.8	1	3.3
Mixed	10	0.7	9	0.7	1	1.4	0	0
Marital Status***	*n* = 1,211		*n* = 1,253		*n* = 70		*n* = 28	
Single	140	11.6	121	9.7	12	17.1	7	25
Married	767	63.3	754	60.2	11	15.7	2	7.1
Divorced	205	16.9	168	13.4	27	38.6	10	35.7
Widowed	239	19.7	210	16.8	20	28.6	9	32.1
Sexual Orientation	*n* = 1,330		*n* = 1,233		*n* = 68		*n* = 29	
Heterosexual	1,294	97.3	1,199	97.2	66	97.1	29	100
Gay	19	1.4	18	1.5	1	1.5	0	0.0
Lesbian	11	0.8	11	0.9	0	0.0	0	0.0
Bisexual	6	0.5	5	0.4	1	1.5	0	0.0
Income***	*n* = 453		*n* = 375		*n* = 54		*n* = 24	
Under US$10,000	96	21.2	69	18.4	16	29.6	11	45.8
US$10,000–24,999	196	43.2	160	42.7	27	50	9	37.5
US$25,000–39,999	161	35.5	146	38.9	11	20.4	4	16.7
US$40,000–59,999	175	15.9	167	44.5	6	11.1	2	8.3
US$60,000–74,999	136	12.2	130	34.7	5	9.3	1	4.2
US$75,000–99,999	154	13.9	154	41.1	0	0.0	0	0.0
US$100,000+	184	16.6	184	49.1	0	0.0	0	0.0

	All Survey Participants		High Food Security		Low Food Security		Very Low Food Security	
Education Level* **	*n* = 1,355		*n* = 1,257		*n* = 70		*n* = 28	
No high school diploma	71	5.2	65	5.2	3	4.3	3	10.7
High school diploma or GED	236	17.4	210	16.7	19	27.1	7	25
Some college, no degree	263	19.4	228	18.1	27	38.6	8	28.6
Associate's degree	138	10.2	129	10.3	6	8.6	3	10.7
Bachelor's degree	344	25.4	333	26.5	7	10	4	14.3
Graduate or professional degree	303	22.4	292	23.2	8	11.4	3	10.7
Employment Status* **	*n* = 1,298		*n* = 1,203		*n* = 68		*n* = 27	
Full-time	265	3.0	258	19.3	6	0.5	1	3.7
Part-time	110	18.9	110	8.2	0	0.0	0	0.0
Self-employed	43	3.0	41	3.1	2	0.2	0	0.0
Unemployed, seeking work	13	0.9	11	0.8	1	0.1	1	3.7
Enrolled in a work training program	8	0.6	8	0.6	0	0.0	0	0.0
Retired, seeking work	38	2.8	30	2.2	5	0.4	3	11.1
Retired, not seeking work	743	53.1	696	52.2	36	52.9	11	40.7
Disabled, unable to work	78	5.9	49	3.7	18	26.5	11	40.7
Regions of Residence* **	*n* = 1,388		*n* = 1,283		*n* = 74		*n* = 31	
Urban	994	71.6	911	71	61	82.4	22	59.5
Rural	73	5.3	64	5	4	5.4	5	16.1
Partially Rural	321	23.1	308	24	9	12.2	4	12.9
Immigrant Status*	*n* = 1,349		*n* = 1,251		*n* = 70		*n* = 28	
Yes	33	2.4	31	2.5	0	0	2	7.1
No	1,316	97.6	1,220	97.5	70	100	26	92.9
Veteran Status	*n* = 1,341		*n* = 1,242		*n* = 70		*n* = 29	
Yes	171	12.8	166	13.4	5	7.1	0	0.0
No	1,170	87.2	1,076	86.6	65	92.9	29	100

* $p < .05$ (X^2 statistic), ** $p < .01$ (X^2 statistic), *** $p < .001$ (X^2 statistic)

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Identifying characteristics of first-time use of charitable community food resources during the COVID-19 pandemic

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Abstract

While national trends in food insecurity prevalence were unchanged in the early COVID-19 pandemic, evidence suggests that millions of people sought food assistance from charitable community sources for the first time during this period. Understanding the characteristics of first-time users of charitable community food resources may inform future emergency food system responses. This study aimed to identify sociodemographic, household,

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and food access–related factors associated with first-time use of charitable community food resources among low-wage workers in 2020. We conducted a secondary analysis of 2020 data from the Wage$ Study, a cohort of low-wage workers in Raleigh, North Carolina (NC), and Minneapolis, Minnesota (MN). Participants (N = 565) reported their sociodemographic characteristics, experiences of personal and household hardships, food access disruptions, participation in the Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and use of charitable community food resources (defined as food pantries and soup kitchens) during stay-at-home orders from March 2020 to June 2020. To examine multilevel factors associated with first-time use of charitable community food resources, we used descriptive statistics, classification tree analysis, and logistic regression. The prevalence of first-time use of charitable community food resources was 29.0%. Classification tree analysis identified older age, race/ethnicity, receipt of church assistance, and encountering out-of-stock foods at one's local grocery store as key factors associated with first-time use. Logistic regression revealed that SNAP participants had higher odds of first-time community resource use compared with nonparticipants. Charitable food programs were important for low-wage workers experiencing barriers to food access during the early pandemic. Strengthening both charitable food systems and federal nutrition programs may improve emergency food access during future crises.

Keywords
food insecurity, charitable food, COVID-19, pandemic, food system, community health, food pantry

Introduction
According to the U.S. Department of Agriculture (USDA), food insecurity occurs when households have limited access to adequate food due to a lack of money or other resources (Coleman-Jensen et al., 2021). The food insecurity rate in the U.S. remained stable at 10.5% for 2019 and 2020, according to nationally representative data collected as part of the USDA Economic Research Service Current Population Survey Food Security Supple-

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Author Contributions
CA led study conceptualization, formal analysis, data interpretation, and writing–original draft. VC contributed to formal analysis, data interpretation, and writing–review & editing. KMG contributed to conceptualization, data interpretation, and writing–review & editing. MEW contributed to conceptualization, methodology, data interpretation, and writing–review & editing. RX contributed to conceptualization, methodology, data interpretation, and writing–review & editing. MGV contributed to formal analysis, data interpretation, and writing–review & editing. CEC contributed to funding acquisition, conceptualization, supervision, data interpretation, and writing–original draft and review & editing.

Ethical Considerations
All human subjects procedures were performed in compliance with relevant laws and institutional guidelines, and were approved by the Institutional Review Boards at the University of Minnesota (STUDY00002094; initial approval December 22, 2017), the University of North Carolina (18-0168; initial approval March 14, 2018), and the University of Connecticut (H20-0087; initial approval July 31, 2020). The privacy rights of human subjects were observed.

Consent to Participate
Written informed consent was obtained from all participants for interactions with human subjects.

Consent for Publication
Not applicable; this manuscript contains no identifiable individual person data.

Data Availability
The study codebook is publicly available at https://doi.org/10.6084/m9.figshare.28360268.v3, and the study instruments are publicly available at https://doi.org/10.6084/m9.figshare.28282910.v1. The analytic dataset used for this manuscript is not publicly available due to confidentiality protections but may be made available from the corresponding author upon reasonable request and subject to institutional approval.

ment (Coleman-Jensen et al., 2021). While trends from this data source did not show statistically significant increases in food insecurity during the first year of the COVID-19 pandemic (Coleman-Jensen et al., 2021), evidence exists to show that some demographic groups–such as racial and ethnic minorities and single-parent households–did experience increases in food insecurity, especially in the early months of the pandemic (Adams et al., 2020; Kowalski et al., 2021; Williams et al., 2024). A number of pandemic-related factors may have driven this increase in food insecurity among certain groups, including the economic downturn associated with business closures, loss of employment, and disruptions in school meal programs that many low-income families relied upon during school closures (Moreland et al., 2020; Niles et al., 2020; Wolfson & Leung, 2020). The pandemic also exposed and exacerbated existing disparities in food access across different demographic groups. Minority communities, mainly Black and Hispanic households, were disproportionately affected by food insecurity during this period due to pre-existing economic vulnerabilities and higher rates of COVID-19 infections (Morales et al., 2021).

In response to these disruptions, federal and state agencies—as well as community organizations—implemented a range of emergency responses. Initiatives included the Coronavirus Food Assistance Program (CFAP), which distributed food boxes at no cost to recipients (USDA, 2020). There was also a significant expansion of federal food assistance programs. SNAP and WIC offered increased benefits and suspended some administrative requirements for participants (Dunn et al., 2020). Specifically, many states offered temporary emergency allotments, allowing all SNAP participants to receive the maximum benefit amount for their household size or an increase of US$95, whichever was greater. However, these expansions did not uniformly reach those in need of food assistance. For example, increases in SNAP benefits were less likely to reach those who were newly unemployed (Fang et al., 2022).

As a result of pandemic disruptions, many households turned to food assistance from charitable food resources, in some cases for the first time (Niles et al., 2020). An estimated 60 million people in the U.S. used a food pantry in 2020, an increase of 50% from the previous year (Feeding America, 2021). Together, community-based charitable resources such as food banks, food pantries, and soup kitchens played a critical role in addressing food access when food need surged (Tian et al., 2022; Feeding America, 2021; Garba et al., 2022). They were also essential in ensuring that households experiencing food insecurity could maintain their fruit and vegetable intake during this time (Bertmann et al., 2021).

The disruptions of the early pandemic highlight how food access behaviors are shaped by factors operating at multiple levels. The socio-ecological model conceptualizes behavior as influenced by interacting factors at the individual, household, community, and policy levels (Bronfenbrenner, 1994). Applying this framework is particularly useful for examining food resource–seeking behaviors during periods of acute disruption, including the early months of the COVID-19 pandemic, when a variety of barriers (such as job loss and business closures) and supports (such as economic relief measures and expansions of food programs) emerged simultaneously across these levels.

The COVID-19 stay-at-home period represents a unique moment characterized by sudden economic and food-access disruption, resulting in an acute shock of food insecurity (Kim-Mozeleski et al., 2023). Examining how individuals engaged with food assistance systems during this period provides insight into how households navigate this acute disruption to food security. Although previous studies have examined pandemic-era shifts in how people obtained or consumed food (O'Connell et al., 2022), the association between food insecurity and participation in food assistance programs (Fang et al., 2022), and the role of community food services during the pandemic (Tian et al., 2021), less is known about the characteristics and multilevel factors influencing first-time use of charitable foods during this period. Individuals engaging with charitable food sources for the first time may have distinct needs and less familiarity with accessing and navigating these programs. Exploring factors associated with first-time engagement can help inform emergency food

system responses and offer targeted outreach strategies.

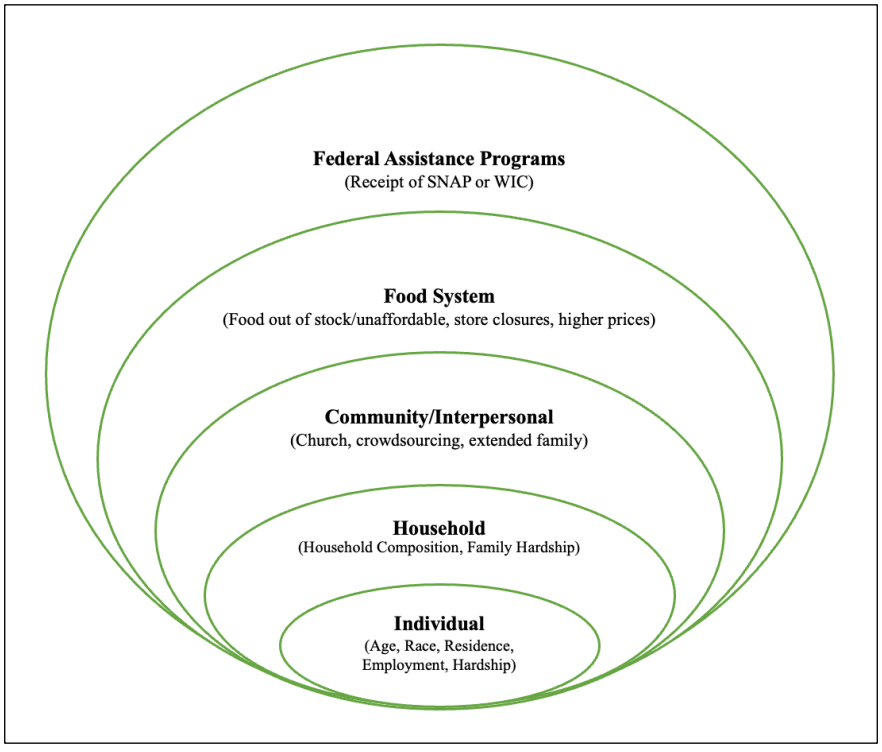
In this study, we apply the socio-ecological model to examine multilevel factors contributing to the complex issue of food insecurity and access. We focus specifically on first-time use of charitable community food resources during the early COVID-19 stay-at-home period, capturing those newly entering the emergency food system during a time of acute need. We aim to identify factors at multiple levels of influence (individual, household, community, food system, and federal programs) during the COVID-19 pandemic associated with first-time use of charitable community food resources, offering insights that may inform efforts to assist those at high risk during future economic or health crises.

Methods

We conducted a secondary analysis of data from the Wage$ Study, which was a prospective cohort study comprising low-wage workers from two U.S. cities: Minneapolis, MN, and Raleigh, NC. This study collected data from 2018 to 2022 to track health and economic outcomes associated with wage increases (Caspi et al., 2021, 2023, 2024; Chapman et al., 2021; Shanafelt et al., 2021). The eligibility criteria for the primary study required individuals to be at least 18 years of age, earn no more than US$11.50 per hour, and work at least 10 hours per week in one of the two study cities (Caspi et al., 2021; Shanafelt et al., 2021). Participants in the study responded to an annual survey that included questions related to food insecurity and food access, receipt of economic and food assistance, and health outcomes. We used data from the third year of the study, collected from July 2020 through January 2021, in this current study of the early COVID-19 pandemic period. The two cities in the study had similar periods in which a "stay-at-home" or "shelter-in-place" order was in effect at the state level, from the last week of March to the third week of May 2020 (Raifman et al., 2021).

We used variables at five levels of the socio-ecological model to examine their association with the first-time use of charitable community food resources during the COVID-19 pandemic. We organized these variables into individual, household, community, food system, and federal nutrition program factors (Figure 1). Individual factors include the following variables: age categorized as 18-29, 30-39, 40-49, 50-59, and 60+ years; race/ethnicity, categorized as Non-Hispanic Black, Non-Hispanic White, Hispanic, and Non-Hispanic Other; and experiencing an individual-level hardship in the last 12 months. Hardships were assessed by the survey question, *"Which of the follow-*

Figure 1. Multilevel Factors Hypothesized to Influence First-Time Use of Charitable Community Food Resources among Low-Wage Workers



SNAP = Supplemental Nutrition Assistance Program
WIC = Special Supplemental Nutrition Program for Women, Infants and Children

ing hardships did you or your family experience in the last year (12 months)?" Participants affirmed whether they experienced each hardship ("Yes" or "No"). Individual-level hardships included having medical procedures or emergencies ("Medical Event"), having disruptions in employment to the individual ("Employment Hardship"), having an arrest or incarceration ("Legal Hardship"), experiencing homelessness, or having a loss of transportation ("Housing/Transportation Hardship").

Household-level factors included household composition (one or more adults with no children, single adults with children, and multiple adults with children), began caring for a loved one, and disruptions in employment or the death of someone in the household ("Family Hardship").

Community-level factors included location or city of residence (Raleigh, NC, or Minneapolis, MN). Additionally, participants were asked, "*Did you receive financial support from any of these sources during the stay-at-home order?"* Participants responded "Yes," "No," or "Unsure" to whether they had received financial assistance from a church ("Church Assistance"), financial assistance from crowdsourcing ("Crowdsourcing"), or financial assistance from extended family ("Family Assistance").

At the food system level, the survey asked participants to answer "Yes" or "No" to a series of questions about the impacts they experienced in their local food system. The question asks, "*During the stay-at-home order, were your typical food shopping activities affected in any of the following ways?"* Items included being unable to buy typical foods because they were out of stock ("Food Out of Stock"), an affordable size or brand of food being unavailable ("No Affordable Food Available"), food prices being higher than usual ("Higher Food Prices"), or the store where they typically shop was closed ("Grocery Store Closure").

Federal nutrition program factors include whether participants received SNAP or WIC during the early COVID-19 pandemic. Participants were asked, *"In the last month (30 days), did you or anyone in your household receive any of the following?"* Responses included food stamps (SNAP or EBT) and WIC. Participants responded with answers "Yes," "No," or "Unsure." We categorized participants who said they were "Unsure" as not receiving these programs (n = 5 for SNAP and n = 2 for WIC).

The dependent variable in this study is the individual and household self-reported first-time experience with food resources during the early COVID-19 pandemic. Participants were asked, *"Which of the following food support resources did you or anyone in your household use for the first time during the stay-at-home order?"* Options of "Food shelf or pantry," "Soup Kitchen," "Garden," and "Other" were given. In Minnesota, places that distribute food at no cost are often referred to as "food shelves," instead of the more common term "food pantries." We assessed these responses as a single binary outcome variable for first-time use of charitable community food resources, such as a food shelf, pantry, or soup kitchen. We excluded responses for "Garden" or "Other," as these may not fall within the category of charitable community food resources.

We conducted statistical analyses using SAS (ver. 9.4). We conducted chi-squared tests to compare individual, household, community, food system, and federal food program–level characteristics by first-time use of charitable community food resources. We conducted a classification tree analysis to assess the impact of individual, household, community, food system, and federal program factors on participants' first-time use of charitable community food resources (Lemon et al., 2003). Classification trees are a statistical technique that identifies subgroups based on their likelihood of experiencing a dichotomous outcome (here, first-time use of charitable community food resources). Classification tree analysis begins by examining the entire sample (called the parent node) and selects independent variables that result in a split into two groups (called child nodes) to maximize differences between these groups. Then the algorithm repeats this partitioning procedure recursively unless stopping rules are met, resulting in subgroups known as terminal nodes (leaves). We used cost-complexity pruning to guide the selection of tree size and avoid overfitting. To assess model performance and variable importance, we examined trees with varying numbers of leaves. We evaluated model fit, including Area Under the Curve (AUC) and entropy, and exam-

ined consistency in variable importance rankings across candidate trees.

Additionally, we conducted logistic regression to examine multilevel factors associated with first-time use of charitable community food resources. The model-building approach added a set of variables at each level of the socio-ecological model (individual, household, community, food system, federal food program) in each subsequent version of the logistic regression model. The logistic regression model was specified as follows:

$$\text{logit}\big(P(Y_i = 1)\big) = \beta_0 + \beta_1 \mathrm{X}_i^{(ind)} + \beta_2 \mathrm{X}_i^{(hh)} + \beta_3 \mathrm{X}_i^{(comm)} + \beta_4 \mathrm{X}_i^{(food)} + \beta_5 \mathrm{X}_i^{(fed)}$$

where $P(Y_i = 1)$ indicates first-time use of community food resource for participant i; β_0 represents the log-odds of first-time use for participants not reporting first-time use of charitable community food resources and who had 0 values for all covariates; $\beta_1 \mathrm{X}_i^{(ind)}$ represents the vector of coefficient and corresponding individual-level covariates; $\beta_2 \mathrm{X}_i^{(hh)}$ represents the vector of coefficients and corresponding household-level covariates; $\beta_3 \mathrm{X}_i^{(comm)}$ represents the vector of coefficients and corresponding community-level covariates; $\beta_4 \mathrm{X}_i^{(food)}$ represents the vector of coefficients and corresponding food system-level covariates; $\beta_5 \mathrm{X}_i^{(fed)}$ represents the vector of coefficients and corresponding federal food assistance covariates.

In addition, as a sensitivity analysis, we collapsed categories with small cell sizes with other similar categories and carried out logistic regression models with the collapsed categories to determine whether results changed.

Results

Of the 647 participants who completed the study survey measure in 2020, we excluded those with missing data on gender (n = 7), race or ethnicity (n = 22), receipt of WIC (n = 5), receipt of SNAP (n = 12), food system questions (n = 23), and household type (n = 13), resulting in an analytic sample of 565 adults.

Overall, 29.0% of low-wage workers in our study reported using a charitable community food resource for the first time during the COVID-19 stay-at-home order. Several factors were associated with the first-time use of these charitable community food resources (Table 1). Low-wage workers who first used charitable community food resources were more likely to care for a loved one (p = 0.02), have older age ($p < 0.01$), have received SNAP ($p < 0.01$), and have their location (city of residence) be Minneapolis, MN ($p < 0.01$; Table 1). All food system-level factors, including grocery store closures ($p < 0.01$), experiencing higher food prices ($p < 0.01$), the unavailability of affordable food ($p < 0.01$), and food being out of stock ($p < 0.01$), also differed by first-time use of charitable community food resources (Table 1).

Results of the cost-complexity pruning analysis examining trees with 10–15 leaves are presented in Appendix Table A1. Improvements in model performance plateaued after 12–13 leaves, and at this point the ranking of the most important variables remained stable across candidate trees. Based on these patterns, we selected a classification tree with 13 leaves as the final model. The final classification tree had an AUC of 0.73. AUC is a statistic that determines how effective a binary classification is, with scores closer to 1 indicating better model performance. Entropy across nodes was 0.76 for first-time use of charitable community food resources, indicating a moderate level of heterogeneity across subgroups.

Results of the classification tree are presented in Table 2 and Figure 2. Factors at multiple levels of the socio-ecological model had high importance scores in training the classification tree (Table 2). Age emerged as the most important factor contributing to the first-time use of charitable community food resources (importance score of 2.88). Church assistance was the second most important factor, with an importance score of 2.46. Race/ethnicity was the third most important factor, with an importance score of 2.42. The tree splits between Hispanic and non-Hispanic participants in 40+ and 18–39 age groups towards the top of the tree. The use of charitable community food resources was 42.9% for those who were older (aged 40+), reported food being out of stock, and had non-Hispanic ethnicity, compared to 11.1% for those

Table 1. Characteristics of Low-Wage Workers from Minneapolis, Minnesota, and Raleigh, North Carolina, by First-Time Use of Charitable Community Food Resources

	First-Time Users of Charitable Community Food Resources *N* (%)	Non–First-Time Users *N* (%)	*p*-value
Gender			
Female	104 (63.6)	247 (61.6)	0.91
Male	59 (36.0)	151 (37.7)	
Nonbinary	1 (0.6)	3 (0.7)	
Age			
18–29	23 (14.0)	116 (28.9)	<0.01
30–39	33 (20.1)	97 (24.2)	
40–49	32 (19.5)	64 (16.0)	
50–59	57 (34.8)	85 (21.2)	
60+	19 (11.6)	39 (9.7)	
Race/Ethnicity			
Non-Hispanic Black	116 (70.7)	286 (71.3)	0.49
Hispanic	7 (4.3)	19 (4.7)	
Non-Hispanic Other	14 (8.5)	21 (5.2)	
Non-Hispanic White	27 (16.5)	75 (18.7)	
Location			
Minneapolis, MN	95 (57.9)	175 (43.6)	<0.01
Raleigh, NC	69 (42.1)	226 (56.4)	
Household Type			
No Children	107 (65.2)	246 (61.4)	0.55
Single Adult with Children	21 (12.8)	65 (16.2)	
Multi-Adult with Children	36 (22.0)	90 (22.4)	
Began Caring for Loved One	22 (13.4)	29 (7.2)	0.02
Medical Event	35 (21.3)	66 (16.5)	0.17
Legal Hardship	4 (2.4)	10 (2.5)	0.97
Housing/Transportation Hardship	40 (24.4)	74 (18.5)	0.11
Employment Hardship	87 (53.1)	223 (55.6)	0.58
Family Hardship	43 (26.2)	105 (28.2)	0.99
Family Assistance	60 (36.6)	119 (29.7)	0.11
Church Assistance	17 (10.4)	13 (3.2)	<0.01
Crowdsourcing	3 (1.8)	8 (2.0)	0.90
Grocery Store Closure	89 (53.6)	154 (38.4)	<0.01
Food Out of Stock at Store	121 (73.8)	224 (55.9)	<0.01
No Affordable Food Available	113 (68.9)	225 (56.1)	<0.01
Higher Food Prices	128 (78.1)	267 (66.6)	<0.01
Received SNAP [a]	105 (64.0)	196 (48.9)	<0.01
Received WIC [b]	16 (9.8)	40 (10.0)	0.94

[a] SNAP = Supplemental Nutrition Assistance Program
[b] WIC = Special Supplemental Nutrition Program for Women, Infants and Children

who were also older and reported food being out of stock, but had Hispanic ethnicity (Figure 2). Non-Hispanic participants aged 40+ who reported food being out of stock, receiving food assistance, having a family hardship, and having begun caring for a loved one had the highest percentage of participants who reported first-time use of charitable community food resources (100%). In contrast, participants aged 18–39 who did not receive financial assistance from a church and did not report that affordable food was unavailable had the lowest percentage of participants who reported using a community food resource for the first time (9.2%).

The adjusted logistic regression models met the convergence requirements. Several factors emerged as predicting first-time use of charitable community food resources in adjusted logistic regression models (Table 3). This included those aged 40-49 (33.3%, aOR = 2.70, 95% CI = 1.34–5.43), 50-59 (40.1%, aOR = 3.25, 95% CI = 1.66–6.37), and 60+ years (32.8%, aOR = 2.86, 95% CI = 1.23–6.63), compared with those aged 18–29 years (16.6%, Table 3). Participants who reported receiving financial support from a church were more likely to use a community food resource for the first time (aOR = 2.55, 95% CI = 1.12–5.80).

Table 2. Variable Importance in Classification Tree Analysis for First-Time Use of a Community Food Resource among Low-Wage Workers from Minneapolis, Minnesota, and Raleigh, North Carolina

Variable	Importance	Relative Importance
Age (40+ years)	2.88	1.00
Church Assistance	2.46	0.85
Race/Ethnicity	2.42	0.84
No Affordable Food Available	2.27	0.79
Began Caring for Loved One	1.79	0.62
Food Out of Stock at Store	1.55	0.54
Gender	1.54	0.54
Family Hardship	1.47	0.51
Received Assistance from Family	1.36	0.47
Grocery Store Closure	1.18	0.41

Participants who reported food being out of stock at their local grocery also had an increased likelihood of using these community resources (aOR = 2.03, 95% CI = 1.14–3.63) compared with those who did not. Finally, participants who received SNAP were more likely to use a charitable community food resource compared with those who did not (aOR = 1.54, 95% CI = 1.02–2.33; Table 3).

Some statistically significant factors in early models were attenuated in the full model, including variables at all levels of the socio-ecological model. For example, participants living in Minneapolis were more likely to use a community resource in the community-level model (aOR = 1.78, 95% CI = 1.17-2.73) and the food-system level model (aOR = 1.59, 95% CI = 1.00-2.52), but these factors were no longer significant in the federal program level model (aOR = 1.51, 95% CI = 0.95-2.41; Table 3). In sensitivity analyses, results of the logistic regression models did not change after collapsing categories with small cell sizes (results not shown).

Discussion

In this study, we identified multilevel characteristics of low-wage workers who are more likely to use food pantries or soup kitchens for the first time during the pandemic. We used a classification tree to identify relevant factors at each level of the socio-ecological model that contribute to new use of charitable foods during the stay-at-home orders that were in effect during the early months of the COVID-19 pandemic. Older age, receiving church assistance, and food being out of stock at the store emerged as important factors in both the classification tree and logistic regression models. The classification tree identified subgroups of individuals aged 18–39 who experienced unaffordable or out-of-stock food and had received financial assistance from a church as having a notably higher likelihood of using a community resource for the first time during the stay-at-home order. These results can inform policymakers who are charged with allocating resources through federal and local food assistance programs during times of crisis. Results may also be useful for community food assistance programs when conducting outreach targeting those who may have the greatest need for assistance and outreach during crises.

Charitable community food resources, such as soup kitchens or food pantries, were essential for millions of families during the COVID-19 pandemic (Feeding America, 2021; Hunger Solutions, 2021). The stay-at-home period is notable, especially in Minneapolis, as it coincided with a period in June 2020 in which the city was the epicenter of civil unrest, which resulted in both the closure of food retail stores and the emergence of pop-up food distribution sites (Caspi et al., 2023; Klecker, 2020). Although the frequency of charitable food use was higher for participants in Minneapolis, a notable portion of participants in Raleigh, and more than a quarter of our study sample, reported using a soup kitchen and/or food pantry for the first time during the 2020 stay-at-home period. While government assistance programs may have restrictions on benefits due to eligibility and application processes, these charitable community food resources provide direct assistance to those in acute need regardless of income, citizenship, or other factors. These resources, while able to provide direct assistance, may still be limited in their ability to meet needs due to transportation barriers, service hours, stigma, and resource limitations (Hazzard et al., 2024; McCarthy et al., 2025).

Figure 2. Classification Tree of First-Time Use of Charitable Community Food Resources by Low-Wage Workers from Minneapolis, Minnesota, and Raleigh, North Carolina, During the Stay-at-Home Orders During the COVID-19 Pandemic

Percentages indicate % of people in the box who used a community food resource for the first time; shaded outlined boxes = Greater than 50% in the affirmative.

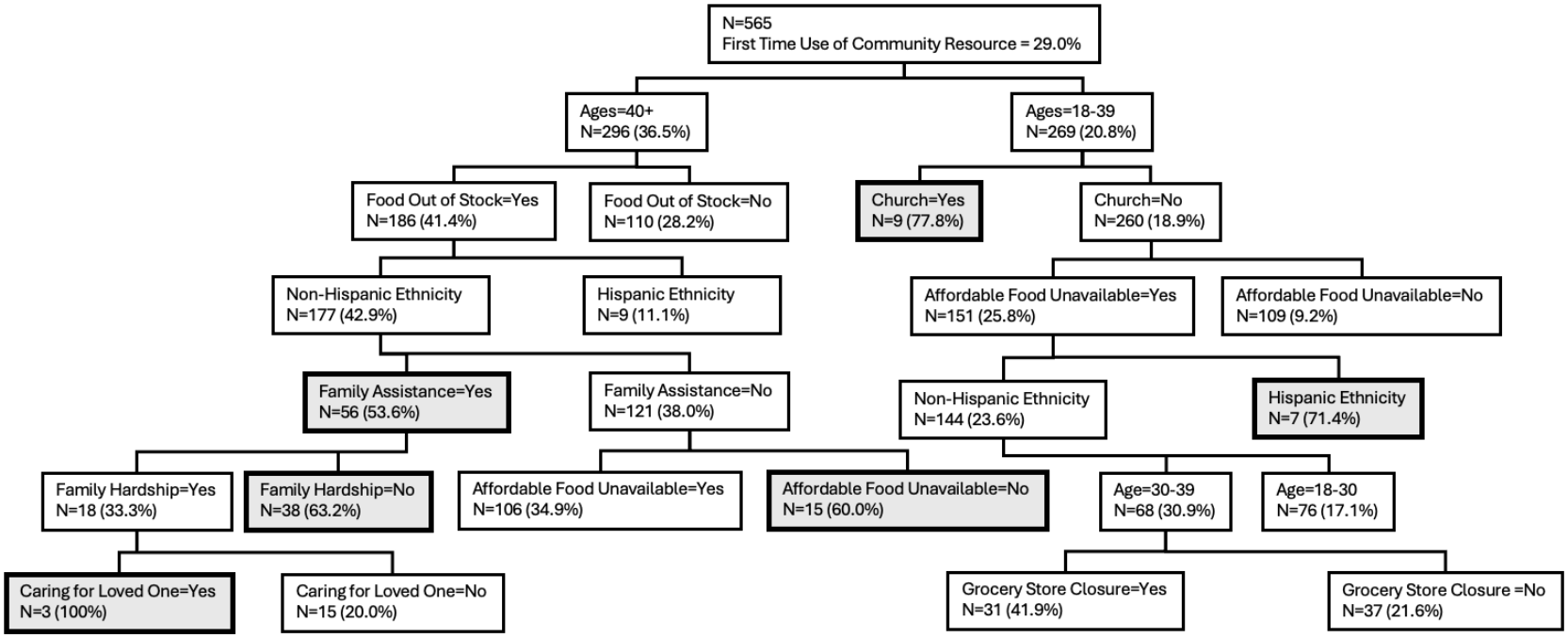


Table 3. First-Time Use of a Community Food Resource among Low-Wage Workers from Minneapolis, Minnesota, and Raleigh, North Carolina, in Relation to Individual-, Household-, Community-, Food System-, and Federal Food Program-Level Factors

Boldface indicates statistical significance at the alpha = 0.05 level.

	First-time use of charitable community food resources, *n* (%)	Individual-level factors, aOR (95% CI) [a, b]	Household-level factors, aOR (95% CI) [a]	Community-level factors, aOR (95% CI) [a]	Food System–level factors, aOR (95% CI) [a]	Federal Food Program-level factors, aOR (95% CI) [a]
Gender						
Female	104 (29.6)	Ref	Ref	Ref	Ref	Ref
Male	59 (28.1)	0.83 (0.56–1.24)	0.86 (0.57–1.30)	0.81 (0.53–1.24)	0.86 (0.56–1.33)	0.91 (0.59–1.41)
Nonbinary	1 (25.0)	1.60 (0.15–16.71)	1.63 (0.15–17.42)	1.61 (0.15–17.36)	2.18 (0.20–23.98)	2.15 (0.20–23.51)
Age						
18–29	23 (16.6)	Ref	Ref	Ref	Ref	Ref
30–39	33 (25.4)	1.81 (0.98–3.34)	1.77 (0.95–3.30)	1.86 (0.98–3.52)	1.75 (0.92–3.34)	1.82 (0.93–3.56)
40–49	32 (33.3)	**2.84 (1.50–5.38)**	**2.95 (1.52–5.70)**	**2.91 (1.49–5.69)**	**2.71 (1.38–5.33)**	**2.70 (1.34–5.43)**
50–59	57 (40.1)	**3.76 (2.09–6.76)**	**3.82 (2.05–7.09)**	**3.39 (1.80–6.40)**	**3.33 (1.73–6.38)**	**3.25 (1.66–6.37)**
60+	19 (32.8)	**2.78 (1.34–5.78)**	**3.09 (1.43–6.67)**	**2.79 (1.26–6.19)**	**2.84 (1.25–6.44)**	**2.86 (1.23–6.63)**
Race/Ethnicity						
Non-Hispanic Black	116 (28.9)	Ref	Ref	Ref	Ref	Ref
Hispanic	7 (26.9)	0.81 (0.33–2.03)	0.79 (0.32–1.98)	0.75 (0.30–1.91)	0.72 (0.28–1.86)	0.74 (0.28–1.95)
Non-Hispanic Other	14 (40.0)	2.06 (0.97–4.34)	2.09 (0.98–4.49)	1.81 (0.83–3.95)	1.74 (0.79–3.86)	1.72 (0.77–3.83)
Non-Hispanic White	27 (26.5)	0.83 (0.50 - 1.38)	0.82 (0.49 - 1.37)	0.71 (0.42 - 1.21)	0.73 (0.42 - 1.25)	0.72 (0.42–1.24)
Medical Event						
No	129 (27.8)	Ref	Ref	Ref	Ref	Ref
Yes	35 (34.7)	1.39 (0.86–2.25)	1.34 (0.82– 2.19)	1.31 (0.80– 2.16)	1.28 (0.77– 2.13)	1.24 (0.74– 2.08)
Legal Hardship						
No	160 (29.4)	Ref	Ref	Ref	Ref	Ref
Yes	4 (28.6)	1.01 (0.29–3.47)	0.98 (0.27–3.51)	1.10 (0.30–4.04)	1.14 (0.31–4.22)	1.09 (0.29–4.08)
Housing/Transportation Hardship						
No	124 (27.5)	Ref	Ref	Ref	Ref	Ref
Yes	40 (35.1)	1.41 (0.88–2.24)	1.42 (0.88–2.27)	1.38 (0.85–2.23)	1.36 (0.84–2.22)	1.38 (0.85–2.24)
Employment Hardship						
No	77 (30.2)	Ref	Ref	Ref	Ref	Ref
Yes	87 (28.1)	1.04 (0.71–1.54)	1.08 (0.73–1.61)	1.18 (0.78–1.77)	1.16 (0.76–1.75)	1.16 (0.76–1.76)
Household Type						
No Children	107 (30.3)		Ref	Ref	Ref	Ref
Single with Children	21 (24.4)		1.04 (0.57–1.93)	1.08 (0.58–2.00)	1.09 (0.58–2.03)	0.89 (0.46–1.72)
Multi with Children	36 (28.6)		1.14 (0.68–1.91)	1.12 (0.67–1.90)	1.16 (0.68–1.98)	1.02 (0.58–1.78)

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Caring for Loved One					
No	142 (27.6)	Ref	Ref	Ref	Ref
Yes	22 (43.1)	1.82 (0.97 - 3.42)	1.89 (0.99 - 3.60)	1.74 (0.90 - 3.35)	1.71 (0.89 - 3.35)
Family Hardship					
No	121 (29.0)	Ref	Ref	Ref	Ref
Yes	43 (29.0)	0.80 (0.51–1.25)	0.77 (0.49–1.22)	0.75 (0.47–1.19)	0.75 (0.47–1.19)
Family Assistance					
No	104 (26.9)		Ref	Ref	Ref
Yes	60 (33.5)		1.37 (0.89–2.10)	1.24 (0.80–1.92)	1.22 (0.79–1.90)
Church Support					
No	147 (27.5)		Ref	Ref	Ref
Yes	17 (56.7)		**3.03 (1.35–6.80)**	**2.82 (1.24–6.38)**	**2.55 (1.12–5.80)**
Crowdsourcing					
No	161 (29.1)		Ref	Ref	Ref
Yes	3 (27.3)		0.41 (0.09–1.87)	0.41 (0.09–1.84)	0.44 (0.10–1.91)
Location					
Raleigh	69 (23.4)		Ref	**Ref**	Ref
Minneapolis	95 (35.2)		**1.78 (1.17–2.73)**	**1.59 (1.00–2.52)**	1.51 (0.95–2.41)
Grocery Store Closure					
No	75 (23.3)			Ref	Ref
Yes	89 (36.6)			1.16 (0.74–1.81)	1.15 (0.74–1.80)
Food Out of Stock at Store					
No	43 (19.6)			Ref	Ref
Yes	121 (35.1)			**1.91 (1.08–3.41)**	**2.03 (1.14–3.63)**
No Affordable Food Available					
No	51 (22.5)			Ref	Ref
Yes	113 (33.4)			0.95 (0.55–1.66)	0.92 (0.52–1.60)
Higher Food Prices					
No	36 (21.2)			Ref	Ref
Yes	128 (32.4)			1.06 (0.64–1.76)	1.05 (0.63–1.75)
Received SNAP [b]					
No	59 (22.4)				Ref
Yes	105 (34.9)				**1.54 (1.02–2.33)**
Received WIC [b]					
No	148 (29.1)				Ref
Yes	16 (28.6)				1.35 (0.64–2.87)

[a] Adjusted logistic regression models include all variables in that column.

[b] Abbreviations: aOR = adjusted odds ratio; SNAP = Supplemental Nutrition Assistance Program, WIC = Special Supplemental Nutrition Program for Women, Infants and Children

Our results revealed that low-wage workers aged 40 years and older were more likely to use the community food resources for the first time compared to those aged 18–29 years. A study examining U.S. adults age 60 and above revealed that food insecurity rates were much higher for those who lived in multigenerational households or were disabled, unemployed, or living on a fixed income (Ziliak & Gundersen, 2022). Complicated application processes for government assistance programs may also contribute to older adults opting for charitable community food resources (Mabli & Worthington, 2017).

Results of the classification tree reveal a complex intersection of personal and community factors associated with seeking out charitable community food resources. Factors at these levels appear multiple times throughout the classification tree. Studies have demonstrated that those living in predominately Black or Hispanic neighborhoods face increased barriers to accessing healthy foods due to limited access to grocery stores (Bower et al., 2014; Powell et al., 2007; Zhu, 2022). While race/ethnicity was an important factor in training the classification tree, additional factors, such as age and interactions with the food system, compounded the direction of this relationship among Hispanic participants. Older Hispanic participants in our study utilized charitable community food resources less frequently than older non-Hispanic participants. Evidence from the pandemic demonstrated that, while Black and Hispanic adults were more likely to use a food pantry, they also faced increased barriers to access, including language barriers for those whose first language is not English (Marriott et al., 2022; Treloar et al., 2024). This, along with factors such as the cultural appropriateness of food offered in the charitable food system, may explain why an older Hispanic population would be less likely to seek them out (Cordeiro et al., 2018).

Several studies reveal that food shoppers in racial minority communities have used mitigation strategies to navigate their resource-poor areas (Antrum et al., 2024; Colón-Ramos et al., 2018). These strategies include reliance on their social network and church, and participation in SNAP and school lunch programs to help make ends meet for their family (Colón-Ramos et al., 2018). It is possible that those who responded that they had received financial assistance from a church also received food assistance from a church food pantry or food kitchen located on the premises. Alternately, church staff may have provided referrals or recommendations for other community resources as part of their assistance to members of their congregations. While the literature on the impact of faith-based charitable food resources on reducing food insecurity is limited, researchers recognize the role of faith-based organizations in the charitable food system (Fishbein et al., 2023; Riediger et al., 2022). A descriptive analysis of food pantries in 12 states across the U.S. found that most food pantries in operation were affiliated with a religious organization (Riediger et al., 2022). The precise role and mechanism through which religiously-affiliated organizations promote food security in times of crisis has not been well documented, and should continue to be studied in future research. Understanding the role of churches and other faith-based organizations in offering emergency services will be essential as cuts to U.S. federal nutrition assistance programs are currently being implemented (Bleich & Seligman, 2026). At the same time, stakeholders should continue to advocate for federal food assistance programs that meet the needs of all citizens regardless of their religious affiliation.

Receipt of SNAP appeared as an important variable in the logistic regression models but not the classification tree. The differing role of SNAP participation in these results may reflect methodological differences. While logistic regression estimates adjusted for associations between independent and dependent variables, classification trees identify variables that best split the sample into more homogenous subgroups. Variables that are significant in regression models may not emerge as the best variables for splitting groups if they do not improve subgroup splits. In the regression models, participants receiving SNAP were more likely to have used charitable community food resources for the first time than those not receiving SNAP. The relationship between SNAP participation and receipt of assistance from food pantries or soup kitchens is complex. On the one hand, SNAP is designed to address food insecurity, so those

receiving SNAP may not need other assistance. Yet, previous studies have demonstrated that the benefits provided by SNAP are not always sufficient, and individuals receiving assistance from SNAP may also seek support from charitable community food resources (Lambie-Mumford & Dowler, 2015; Mabli & Worthington, 2017). A study examining food assistance during the COVID-19 pandemic found that SNAP participants still utilized other charitable community food resources, but likely to a lesser extent than expected, due to the emergency allotments that temporarily offered the maximum benefit amount for a participant's household size (Taylor et al., 2022). Additionally, food pantries and soup kitchens have the potential to serve a more broad and heterogenous population because many of these agencies do not have strict income limits and can reach people who are inadequately served by federal food assistance programs (Lambie-Mumford & Dowler, 2015).

The results of this study reveal the complex characteristics of individuals who sought charitable community food resources for the first time during the early stages of the COVID-19 pandemic. Because these resources do not have restrictions on who they serve and do not have lengthy enrollment processes, they serve an essential role during short-term crises. Stakeholders should consider the role of each of these services, who seeks their assistance, and how to get more support for these programs when additional federal assistance may be limited. Notably, the USDA also supports charitable food agencies like food pantries. During the pandemic, USDA programs such as The Emergency Food Assistance Program (TEFAP) enabled the increased allocation of food to food banks and allowed participants to receive assistance regardless of qualification or citizenship status (Feeding America, n.d.; USDA, 2026b). Additionally, TEFAP and another USDA program, the Commodity Supplemental Food Program (CSFP), are less susceptible to shocks in the food system as they have access to commodity foods that retailers do not (USDA, 2026a, 2026b). Stakeholders should recognize that government food assistance programs, such as SNAP, may not be as nimble in responding to changes like a lack of affordable food or essential items being out of stock, which are important factors related to people's use of charitable community food resources. The potential chilling effects of current federal policies (The White House, 2025) may cause those in homes with mixed immigration status to rely even more on charitable community food programs (Algert et al., 2006; Bleich & Seligman, 2026; Watson, 2014). Recently, the federal government has abruptly reduced federal funds that support charitable food sources, which could significantly limit their ability to serve those in need (Picchi, 2025). While the federal government should serve a key role in providing funds for these community resources, administrators should look for opportunities at the state or local level to bolster their reach while serving their communities equitably.

This study had several limitations. Participants were asked only whether they used charitable food resources for the first time during the stay-at-home order. As a result, negative responses do not allow us to distinguish those who had never used charitable food resources, those who had used them only in the past, and those who continuously relied on these resources. This lack of distinction is likely to attenuate the associations observed, because the differences between our two comparison groups may be diluted. In particular, prior or continuous users who responded "no" may be more similar to first-time users with respect to food insecurity and household financial insecurity than they are to never-users, who may be more likely to have stable household finances and lower levels of food insecurity. This potential misclassification may bias results towards the null. As an additional limitation, the classification tree analysis was conducted as an exploratory, hypothesis-generating approach to identify potential subgroups and interactions. The relatively modest sample size may have reduced the stability of results for smaller subgroups, and these findings should be interpreted with caution. Logistic regression models did not include interaction terms, although the classification tree captures interactions implicitly. Additionally, the data in this study are from low-wage workers in two U.S. cities. Participants were enrolled based on their status as low-wage workers in 2018, rather than on

their household income. Therefore, the sample is not demographically comparable to low-income households in terms of factors like age and health status. Although our two-site study contributes granular data on multilevel factors associated with first-time use of charitable food resources, it has limited generalizability to other populations, including individuals with higher socioeconomic status, individuals in other geographic regions, and other time periods. However, many COVID-19–related disruptions and federal economic relief expansions were national in scope, which supports the broader relevance of our findings. In future analyses, nationally representative datasets such as the Household Pulse Survey (U.S. Census Bureau, 2020) may be well equipped to address questions about food insufficiency and food pantry visits across states and socioeconomic groups using larger sample sizes.

Conclusion

Charitable community food resources, such as food pantries and soup kitchens, played an important role in supporting household food security during the early COVID-19 pandemic, and are likely to continue to play a large role as federal food assistance programs are scaled back. In this study, we identified subgroups of low-wage workers who were more likely to use these charitable community food resources for the first time during the stay-at-home orders in 2020. These findings help to identify who might be newly reliant on charitable food resources during times of crisis and where charitable food agencies might make changes to better serve the people most in need. These findings also may help inform policymakers and community stakeholders in shaping programs that mitigate food insecurity and offer an understanding of behaviors in times of acute crisis.

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Appendix Table A1. Cost-Complexity Pruning Examining Trees with 10–15 Leaves

Leaves	AUC	Misclass-ification	ASE	Entropy	Importance Rank 1	Importance Rank 2	Importance Rank 3	Importance Rank 4	Importance Rank 5	Importance Rank 6
10	0.7	0.2531	0.1799	0.7767	Age (40+ years)	Church Assistance	No Affordable Food Available	Began Caring for a Loved One	Food Out of Stock	Family Hardship
11	0.71	0.2478	0.1772	0.7681	Age (40+ years)	Church Assistance	No Affordable Food Available	Race/Ethnicity	Began Caring for a Loved One	Food Out of Stock
12	0.72	0.2478	0.176	0.7632	Age (40+ years)	Church Assistance	No Affordable Food Available	Race/Ethnicity	Began Caring for a Loved One	Food Out of Stock
13	0.73	0.2478	0.1748	0.7591	Age (40+ years)	Church Assistance	No Affordable Food Available	Race/Ethnicity	Began Caring for a Loved One	Food Out of Stock
14	0.73	0.2425	0.1733	0.7548	Age (40+ years)	Church Assistance	No Affordable Food Available	Race/Ethnicity	Began Caring for a Loved One	Food Out of Stock
15	0.73	0.2407	0.1722	0.7508	Age (40+ years)	Church Assistance	No Affordable Food Available	Race/Ethnicity	Began Caring for a Loved One	Food Out of Stock

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"I don't say food desert, I say food apartheid": Community-engaged research to understand food insecurity

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Abstract

Physical access to healthy food in the U.S. has been shaped by social and economic structures that include historical segregation and inequities in neighborhood development and investment. African Americans are most likely to reside in these historically segregated and economically challenged neighborhoods that have fewer healthy food options. Consequently, residents face significantly greater barriers to accessing healthy foods. To better understand the food insecurity experiences and food access needs of residents living in predominantly African American neighborhoods, we used a community-based participatory research (CBPR) approach and partnered with a community advisory board (CAB) in an urban Florida community. The CAB sought to capture the experience of living in a food desert by designing data collection tools, and recruiting and interviewing participants who lived or had family ties in Southeast Gaines-

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ville. Between February and December 2021, the team hosted three online focus groups with a total of 17 adult participants and administered a 35-item survey (N = 103). The survey response showing that 48% could not consistently afford to prepare a healthy meal was used as a measure of food insecurity. Significant predictors of this response were whether the participant also worried about running out of food (OR = 0.181, 95% CI [0.058, 0.561]), used Supplemental Nutrition Assistance Program (SNAP) assistance (OR = 0.515, 95% CI [0.266, 0.997]), and occasionally had to avoid their preferred grocery store for some reason (OR = 0.177, 95% CI [0.049, 0.641]). Over one third (37%) of households reported special dietary needs due to health issues, and many of those (39%) said they had trouble meeting those needs. Two major themes emerged from the qualitative data: navigating the structures of food apartheid and community food solutions. Underscoring the need for CBPR approaches to food systems planning and intervention, these results suggest that local knowledge of the food environment is critical for understanding how households in food deserts experience food insecurity and view potential solutions.

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Keywords
food insecurity, food apartheid, African American, community-engaged research, community-based participatory research, community advisory board, food and health disparities, food environment, healthy food affordability, urban

Introduction

Food and nutrition security (FNS) exists when healthy foods are available, affordable, and consistently accessible in ways that promote wellbeing and prevent diseases (Mozaffarian et al., 2021; Simelane & Worth, 2020). The food environment, that is, where residents access their food, shapes FNS and diet-related health outcomes (Bevel et al., 2023; Caspi et al., 2012; Cooksey-Stowers et al., 2017; Gripper et al., 2022; Karpyn et al., 2020; Kraft et al., 2020; Radulescu, 2021; Reese, 2019; Yamaguchi et al., 2022). Food environments, defined as the availability, accessibility, affordability, acceptability, and accommodation of food (Caspi et al., 2012), are situated in the socioecological model of food systems, where they play a critical role in supporting diets because they represent the daily spaces

Ethical Standards Disclosure
This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the University of Florida Institutional Review Board (IRB 202002389). Verbal informed consent was witnessed and formally recorded from all participants.

Authorship
A. Asanzi drafted the manuscript and incorporated revisions from all authors. She was also involved in formulating the research questions, data collection, and data analysis.
M. C. Martin conducted quantitative and qualitative data analysis, was also involved in formulating the research questions and drafting the initial manuscript.
A. Papanek led the literature review process and conducted qualitative data analysis.
D. Ajayi assisted with reviewing and revisiting the manuscript.
A. Allen-Mitchell assisted with literature review and the design of the study.
T. Burton assisted in developing the manuscript outline and contributed to revising and editing the final draft.
B. N. Dixon supervised research provided guidance on study design and supported data interpretation.
P. Monaghan supervised the research, provided guidance on study design, and supported data collection and data analysis.

and structures in which individuals navigate food systems and access the food options that are available to them (Downs et al., 2020). In this model, food environments do not operate in isolation; rather, they interact with other layers of the food systems socioecological model, such as sociocultural and political environments, sectors of influence, and individual factors (Downs et al., 2020). These various scales of systems are drivers of the food environment, influencing individual food purchases, consumption, and FNS (Downs et al., 2020; Nisbett et al., 2022).

The impact of the food environment on FNS is especially pronounced in lower-income and minority neighborhoods where access to healthy food is often limited (Gripper et al., 2022; Kraft et al., 2020; Reese, 2019). African Americans make up a larger population of those living in food deserts and food swamps, as defined by limited access to supermarkets and nutritious foods and by a high density of fast-food outlets, convenience stores, and highly processed foods (Cooksey-Stowers et al., 2020; Goh et al., 2024). According to Cooksey-Stowers et al. (2020), non-Hispanic Blacks in the U.S. are 38% more likely than non-Hispanic whites to be situated in food swamps. These environments are associated with increased risks of diabetes (Baxter & Park, 2024), metabolic dysfunction (Paik et al., 2025), and obesity rates (Bevel et al., 2023), and higher hospitalization rates (Phillips & Rodriguez, 2019), placing Black communities at higher risks of adverse health outcomes.

While most food systems and public health research consistently show that behavioral choices and socioeconomic disadvantages are linked to food health disparities (Alcott et al., 2019), an expanding body of literature highlights the role of food apartheid, a term describing food systems shaped by racist structures, policies, and institutions that produce inequitable food environments and diet outcomes (Burrell, 2022; Gripper et al., 2022; Odoms-Young & Bruce, 2018). In the U.S., historic and contemporary policies and practices—such as redlining, zoning ordinances, transportation routes, and racial discrimination—have created food apartheid (de Souza, 2024; Gripper et al., 2022; Williams & Collins, 2001). These policies and practices place Black individuals at a disadvantage in accessing quality education, employment opportunities, and healthcare (Gripper et al., 2022; Williams & Collins, 2001). These compounding disadvantages perpetuate socio-economic inequalities, producing disinvested neighborhoods (e.g., food swamps and food deserts) where access to healthy food is severely limited (Gripper et al., 2022; Howerton & Trauger, 2017). While the burden of food apartheid falls disproportionately on low-resourced communities (de Souza, 2024), Black individuals with higher income and education levels are not exempt from its effects, as research shows they too experience a high risk of poor diet quality (Hilmers et al., 2012; McCullough et al., 2022).

The complexity of healthy food access and its interconnectedness with socio-economic disadvantages, racist structures, systems, and institutions requires a collaborative approach and the involvement of various stakeholders (Burrell, 2022). Community-based participatory research (CBPR), one of the most used community engagement approaches to engage disadvantaged communities (De Las Nueces et al., 2012; Fleming et al., 2023; Riccardi et al., 2023), enables this type of collaboration. CBPR uses a partnership approach to research and involves community members, practitioners, and academic researchers in the inception, development, implementation, evaluation, and dissemination of knowledge (Doustmohammadian et al., 2022; Israel et al., 2010, 2013; Rollins et al., 2021).

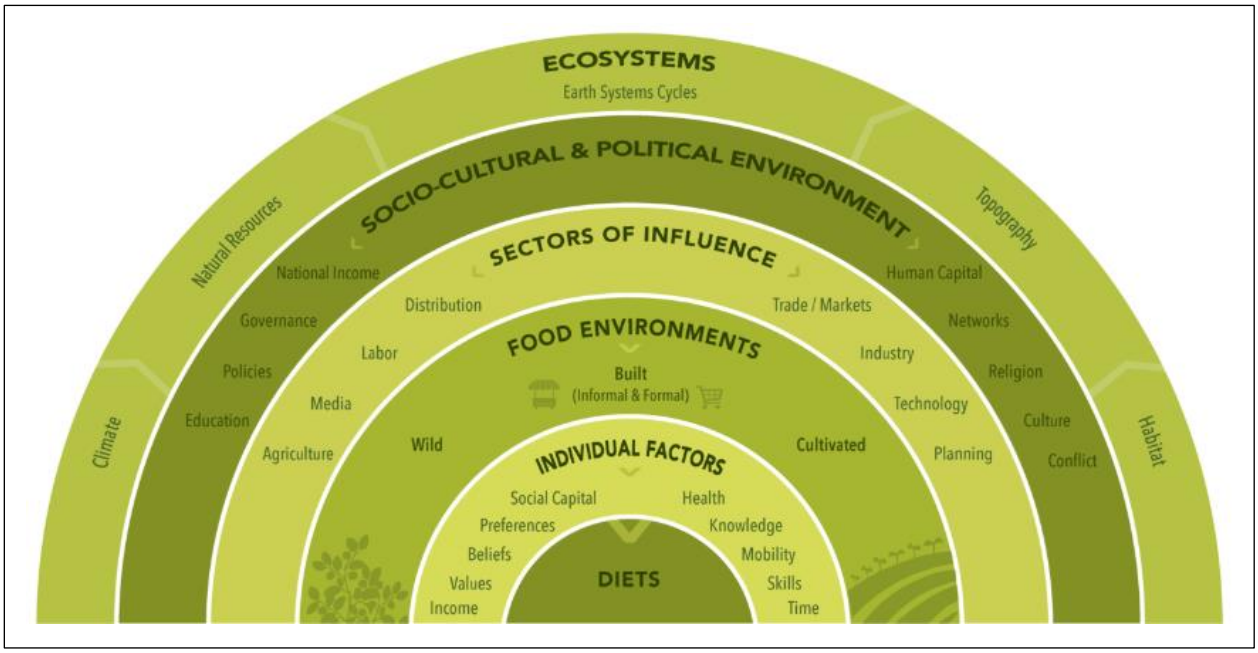
There are different levels of engagement in CBPR, and community members must be involved in at least one of the following stages: identifying the problem, recruitment, intervention development, data collection, and/or dissemination of results (Riccardi et al., 2023). The engagement framework of CBPR makes it a powerful tool to empower communities by building capacity within the community through the research process and involving residents in decision-making (Breland-Noble et al., 2024). Prior research has identified positive outcomes when CBPR was used in health promotion projects. These outcomes included equal partnerships with researchers, increased capacity of community members to create projects that address community needs, improved cultural

sensitivity, and a better dissemination of results (Ortega et al., 2018; Riccardi et al., 2023). While CBPR offers tools and guiding principles to address social and health inequities by engaging with historically disadvantaged communities (e.g., ethnic minorities, Black and Brown communities [Breland-Noble et al., 2024; Fleming et al., 2023]), its implementation is not without challenges. Specifically, the fluid and often ambiguous roles and responsibilities of community members, the devaluation of their knowledge and lived experience, their limited decision-making power, and the inconsistent communication between researchers and community members challenge CBPR's ability to erase inequities and achieve positive outcomes (Ortega et al., 2018; Riccardi et al., 2023).

Decades of community advocacy, public health research, and scholarship on structural racism (Antrum et al., 2024; Black et al., 2014; Cooksey-Stowers et al., 2017; Gripper et al., 2022; Hilmers et al., 2012; Odoms-Young & Bruce 2018) have documented the relationships between race, food access, and poor health outcomes in the U.S. Federal policy responses include the U.S. Department of Agriculture (USDA) Healthy Food Financing Initiative (HFFI) created in 2010 by the Obama Administration to build healthy food stores in historic urban and rural food desert areas (Morland et al., 2022). HFFI is a critical funding mechanism to bring healthy food access to underserved communities (Morland et al., 2022). However, despite the promises of HFFI, low-income and minoritized (or disinvested) communities continue to be impacted by the complex, multilevel ramifications of unequal geographic access, structural racism, and systemic lack of investments to build healthy food systems (Joyner et al., 2022). Because of these factors, policy initiatives and even increasing the physical access to healthy food have demonstrated limited impacts (Allcott et al., 2019; Campbell et al., 2020; Cummins et al., 2014; Dubowitz et al., 2015; Elbel et al., 2015; Packer, 2017; Wright et al., 2016).

A more complete understanding of the multiple factors that shape food and nutrition factors, such as the food systems socioecological model (see Figure 1), also highlight the individual factors that are involved, such as income level, lower education attainment, and insufficient nutrition knowledge (Alcott et al., 2019; McCullough et al., 2022). Beyond individual factors, socio-cultural influences further complicate the relationship between food access and food and nutrition out-

Figure 1. The Socioecological Model of Food Systems



Source: Downs et al., 2020, p. 5.

comes. These outcomes are shaped by social norms, cultural practices (Nisbett et al., 2022), and long-standing purchasing habits rooted in what has historically been available and affordable in local food environments (McCullough et al., 2022; Reese, 2019). Together, these barriers highlight a critical gap in current interventions in food environments, underscoring the need for multilevel approaches that target all layers of the socio-ecological model of food systems.

Often used interchangeably with food sovereignty, food justice has emerged as a response to food system inequities (or food apartheid) that particularly affect disadvantaged communities (Clapp, 2024; Murray et al., 2023). The concept of food justice aligns with social justice goals by advocating for the recognition of human rights, equal opportunity, fair treatment, community participation, and community-specific solutions to food inequities (Murray et al., 2023). It encompasses a transformative approach that goes beyond addressing food affordability, availability, and access.

Study Context

The current study was conducted by a partnership organized by the Grace Grows Community Food Project (GGCFP), a CBPR initiative led by Grace Grows, a local nonprofit organization dedicated to improving local food sovereignty in north-central Florida. The GGCFP team included local leaders, nonprofit staff, volunteers from the Southeast Gainesville community, and graduate students and faculty from the University of Florida (UF) in the Department of Agricultural Education and Communication (AEC), the Department of Family, Youth, and Community Sciences (FYCS), and the College of Public Health and Health Professions (PHHP). The GGCFP was launched in 2021 with the primary goal of conducting a needs assessment to understand the healthy food challenges faced by households in Southeast Gainesville. By incorporating community perspectives through CBPR, the study aims to understand how households navigate structural food environments and the types of barriers to healthy foods.

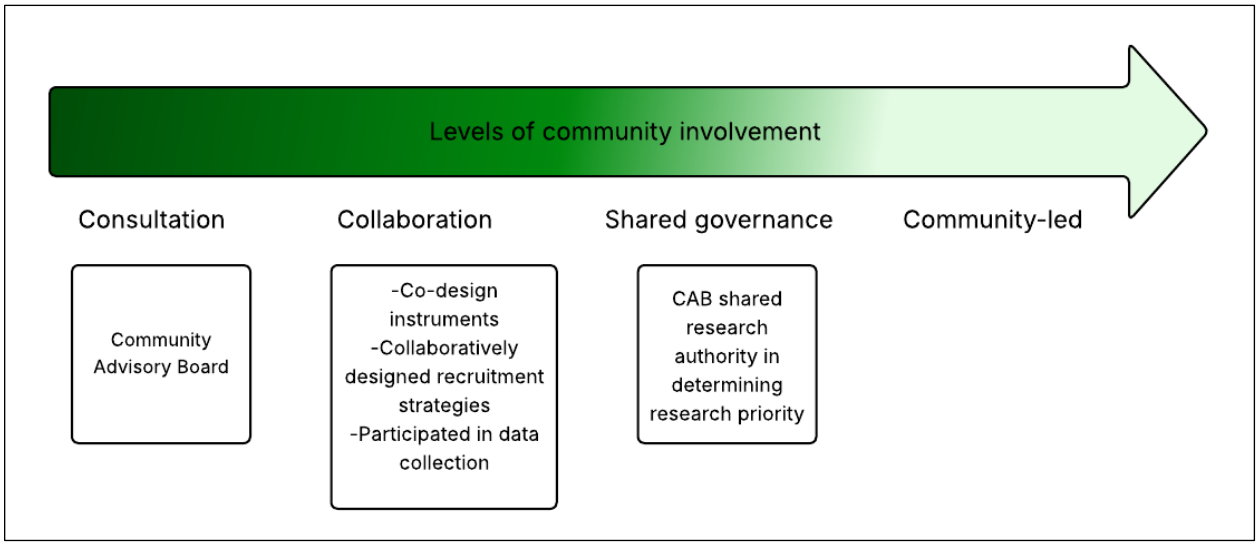
Research Methods

This research was co-designed and administered through both qualitative focus group discussions (three groups) and a quantitative survey (Israel et al., 2010), following a sequential mixed-methods approach comprising a three-phase process (Creswell & Clark, 2017). The first phase entailed two focus groups with residents of Southeast Gainesville, many of whom were parents of school-age children. The second phase was the design and implementation of a survey instrument with the CAB. The third phase involved the final focus group to review and synthesize findings. Institutional review board approval was obtained from the University of Florida (IRB 202002389).

Selection and Engagement with the Community Advisory Board

The community was engaged in nearly all early stages of the study, from the initial development of the research project through data collection (Riccardi et al., 2023). A panel of Project Advisors consisting of leaders in local food justice activities nominated 40 community members who lived or worked in Southeast Gainesville to be considered for the CAB. Fifteen community members (11 females and 4 males), all of whom identified as African American, agreed to participate and were ultimately included in the final CAB. Their eligibility to participate was based on criteria such as community leadership, lack of traditional recognition in position of power, past involvement in food systems, lived experience with food insecurity, and leadership in faith, arts, or social safety networks in the Southeast Gainesville community. The CAB members convened for six monthly meetings and were compensated US$200 per meeting. The members were trained in IRB principles and how to conduct interviews. Additionally, CAB members supported recruitment efforts by identifying potential participants for the study and recommending locations for data collection. Following data collection and analysis, the Project team shared preliminary results of the focus groups and the survey with the CAB to gather insights and develop steps forward. Considering the level of engagement in CBPR as a continuum (see Figure 2), this project was characterized by consultation, collaboration, and shared governance (Carlson et al., 2006; Israel et al., 2010; Pine & de Souza, 2013).

Figure 2. Continuum of Community Engagement Demonstrating This Project's Levels of Collaboration and Participation in the CBPR Framework



Instruments

Data collection tools included focus group questionnaires and a 35-item survey co-designed with the CAB.

Focus Group Development

The Project team created the first focus group discussion (FGD) questions, and two were conducted prior to the survey. This instrument included 10 semi-structured questions on the lived experiences of food insecurity, barriers to food access, dietary needs, community food and health knowledge, use of food assistance, and community-driven solutions (see Appendix A). Using the FGD findings, the Project team and the CAB, collectively referred to as the Research team, developed a preliminary survey. The survey results were then validated in the third focus group with revised questions that captured new emerging themes and topics from the survey (Collins et al., 2006). As a result, the third focus group included additional questions focused on community assets that facilitate food access, solutions to food access challenges, nutrition and culinary education needs, gardening educational needs, barriers to gardening, definitions of healthy eating, existing food resources, and visions for a food-secure future.

Survey Development

The first two focus group results and feedback from the CAB shaped the survey questionnaire so that it would highlight the barriers and facilitators of access to healthy food. The first draft of the questionnaire was presented to the CAB, who then revised the survey questions. The CAB added questions on the definitions of healthy food, perception of dietary health, and frequency of how often they could not afford to prepare a healthy meal (Questions 6, 7, 8; see Appendix A). They also revised questions related to food access, special household dietary needs, and barriers to access (Questions 12 and 14, see Appendix A). Notably, the CAB introduced questions about shopping behaviors, such as "where do you shop?", "have you ever avoided shopping there because it was too difficult?", and "what made it difficult?" Finally, the CAB added questions about food assistance programs, including the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition for Women, Infants, and Children (WIC), and whether these programs helped meet the food needs of the household. The CAB recommended retaining only one item from the USDA Food Security Module: the question assessing how often households worried about running out of food. The result was a 35-question survey including mostly closed-ended Likert-style, yes/no

responses, and seven open-ended questions. It was pilot tested with members of the CAB. The CAB reviewed the pilot test results in a consensus-driven discussion to determine the importance and relevance of each question and then modified the language and content of questions based on priorities, perceived needs, and interests of the community. Table 1 presents CAB-prioritized topics assessed during the survey.

Sample

All participants in both the FGD and survey were recruited using purposeful and convenience sampling, appropriate methods for studying disadvantaged populations (Golzar et al., 2022; Koch & Emrey, 2001; Palinkas et al., 2015). Across all phases of research, the participants' eligibility criteria were that they were (1) 18 years or older, and (2) living, working, or had family in Southeast Gainesville. Since the study location was in predominantly English-speaking African American neighborhoods, all recruitment and research materials were only available in English. In total, participants were recruited across nine neighborhoods of the city where there is a history of structural inequality despite decades of attempts to address it (University of Florida Bureau of Economic and Business Research [BEBR], 2018). East Gainesville has the highest concentration of people living in poverty and those identifying as racial and ethnic minorities in the city of Gainesville (BEBR, 2018; Renaissance Planning Group, 2003). Almost all of Southeast Gainesville is classified as a food desert (USDA Economic Research Service, n.d.).

During the first phase of the research, FGD participants were recruited with the help of the Project Advisors. In the second phase of the research (the survey), participants were recruited from locations or households suggested by the CAB and through intercept recruitment by going door-to-door and approaching caregivers during school pick-up hours to invite them to participate in the study. During door-to-door recruitment, when more than one individual was present in a

Table 1. Survey Topics Prioritized by the Community Advisory Board (CAB)

Constructs	Survey topics/questions
Food access experiences	● Preferred grocery store and why ● Unable to shop at preferred grocery store and why ● Access to transportation ● Asking others for a ride or to help to pick up food ● Worry about running out of food *(only question from the USDA Food Security Module that was retained)*
Healthy foods	● Definition of healthy food ● How often one cannot afford to prepare a healthy meal ● Perception of healthiness of their own diet
Special dietary needs	● Description of special dietary needs ● Difficulty buying food that fits within special diet needs
Interest and willingness to participate in community garden	● Interest in fruit and vegetable gardening, including receiving training for self and for children ● Gardening resources available in the community
Food assistance program use and experiences	● Frequency of food assistance use such as WIC, SNAP,[a] food pantries ● How often food assistance fits household diet needs ● Satisfaction with the quality of food ● Food assistance covers the full month
Community assets	● What residents value about the neighborhood ● List of organizations that you are involved in ● How you stay involved in the community

[a] WIC is the Special Supplemental Nutrition for Women, Infants, and Children; SNAP is the Supplemental Nutrition Program (formerly known as food stamps).

household, the available caregiver was asked to complete the survey. When no adults were present in the household, a copy of the survey along with the Qualtrics survey link was left behind. Information on household characteristics is presented in the results. In the third phase of the research (third focus group), participants who had participated in the survey were recruited using the contact information they had provided.

Data Collection

Two focus groups were conducted in February 2021 with 10 participants total (five participants in each one). Between June and November 2021, the survey was administered in person and self-administered online to a total of 103 respondents. In-person survey administration lasted approximately 30 minutes and was conducted in participants' homes and public spaces, with two members of the research team present for each session. All survey data were recorded as typed responses, whether entered by participants directly or transcribed by interviewers. The third focus group, which included seven participants recruited directly from the survey sample, was held in November 2021 to review survey findings and validate emerging themes. All focus group discussions lasted approximately 60 to 90 minutes and were conducted using Zoom video conferencing (Boland et al., 2022). They were facilitated by a community leader from the research team. Two additional members of the research team were also present as observers. The focus group discussions were audio recorded, deidentified, and transcribed verbatim by a member of the research team using Zoom-generated transcripts as a starting point, followed by cleaning and editing. Consent was obtained verbally for all data collection activities. For participants who self-administered the survey, consent was recorded when the participant agreed to participate using the Qualtrics link to begin the survey.

Data Analysis

Each dataset was analyzed separately. Data analysis was completed by three members of the Project team (two graduate students and one independent researcher), hereafter referred to as analysts. Preliminary results were presented to the CAB.

Qualitative Data Analysis

Qualitative analysis was conducted in MAXQDA 2022 (VERBI Software, 2021) using a structured codebook and an iterative process using both a priori and inductive codes. The analysts met weekly with senior research staff to discuss, review, and define the codes. A second round of coding was conducted to refine and merge codes and to identify prominent themes (Saldaña & Omasta, 2016).

Quantitative Data Analysis

Findings from the focus group data indicated that the ability to afford healthy meals was a significant barrier to food access. Therefore, the primary outcome variable was households' ability to afford healthy meals. This outcome was derived from responses to the survey question, "In a typical year, how often was there a time that you could not afford to prepare a healthy meal?" Healthy foods were defined by participants in the survey through an open-ended survey question. Responses to this question, along with other open-ended questions, were analyzed using content analysis.

Descriptive statistics and binary logistic regression analysis were conducted in SPSS. Descriptive statistics included frequency, means, standard deviation, correlations and chi-square analysis. For analytic clarity and to enhance statistical robustness, the four- and five-point Likert scale items were simplified into binary indicators of 'never' versus all other responses (e.g., often, sometimes, occasionally) to simplify interpretation, reduce sparsity in response categories, and support the assumptions of chi-square and logistic regression (Boone & Boone, 2012; Dolnicar & Grün, 2013). A binary logistic regression was selected because the outcome variable was dichotomous (LaValley, 2008). All predictors were entered simultaneously into the logistic model and their odds ratios were estimated. The ability to afford healthy meals was recoded from a four-point Likert scale to a binary variable, where ability was coded as 0 and inability as 1. Model fit was assessed using the omnibus test of model coefficients. Independence of observations was assumed as each participant contributed one survey response and no repeated measures were included in the analysis. The independent variables were also not highly correlated with each other.

Therefore, we tested the relationship between the dependent variable (the ability to afford healthy meals) and predictors such as worrying about running out of food, use of public transportation, receiving SNAP benefits, and avoiding a preferred grocery store for any reason. Age was included as a covariate.

Results

Table 2 provides the descriptive statistics of the survey sample (N = 103). Demographic data was not collected for focus group participants. More than three-quarters of survey respondents (86%) completed the survey with an interviewer and 14% of respondents self-administered the survey using a Qualtrics link. Forty-two percent of respondents used SNAP and 11% used WIC benefits at least once in the past year. Forty percent of respondents reported worrying about running out of food, 37% indicated that food assistance was sufficient to meet their household food needs for the entire month, and the majority (84%) reported that when food assistance was received, it often or always aligned with their household's dietary needs.

Table 2. Survey Respondent Demographics

	Full Sample	
Characteristic (N = 103)	***n***	**%**
Gender (n = 94)		
Man	19	20.2
Woman	75	79.8
Race/Ethnicity (n = 95)		
American Indian or Native American	4	4.2
Asian	1	1.1
Native Hawaiian or Other Pacific Islander	1	1.1
Black of African American	81	85.3
White	8	8.4
Hispanic/Latinx	4	4.3
Other	8	8.4
Education Level (n = 96)		
Some high school	8	8.3
High school diploma or GED	19	19.8
Some college (no degree)	29	30.2
Trade/technical/vocational training	4	4.2
Higher Education (bachelor, master, doctorate)	36	37.6
ZIP Code (n = 95)		
32641	79	77
32601	5	5
32608	3	3
Other	8	8
Characteristics (N = 103)	**Mean**	**SD**	**Range**
Participant Age (n = 91)	54.6	16.4	67
Household Size (# of adults) (n = 94)	1.84	0.83	3
Household Size (# of children) (n = 92)	0.90	1.32	5
SNAP assistance (n = 97)	2.12	0.98	4
WIC (n = 98)	1.63	1.42	4

Quantitative Results

The section presents the quantitative results. Associations between the ability to afford healthy meals with special dietary needs, food access experiences, worry about running out of food, and avoiding a preferred store were assessed using chi-square analysis. This was followed by a logistic regression analysis to examine the barriers to affordability.

Dietary Restrictions

As a result of pre-existing health conditions, over one third (37%) of the survey respondents reported having special dietary needs in their households, and 38 of them identified such special dietary needs. Those with special dietary needs in their households reported having trouble meeting such needs within the past month (39%). Respondents with affordability challenges were more likely to report trouble meeting special dietary needs, although this

association was not statistically significant (χ^2 = 2.51; p = .11). While 22 respondents reported health conditions experienced either personally or by a family member, including diabetes (n = 7), food allergies (n = 5), food intolerances such as lactose intolerance (n = 5), elevated cholesterol (n = 2), Crohn's disease (n = 2), and dementia (n = 1), 25 identified foods they avoided due to these conditions. Although hypertension was not specifically mentioned as a health concern, six respondents indicated that they had reduced sodium in their diets.

Food Access Experiences: Navigating Food Access Through Social Networks and Transit

Assistance from social networks to obtain food was an important variable for understanding how residents navigate the food environment. Survey data indicates that 34% of participants had asked their neighbors for help getting groceries at least once a month. This help specifically involved either receiving a ride to the store or having groceries picked up for them. Among these participants, a high percentage (64%) reported sometimes not able to afford a healthy meal. Spearman's correlation analysis found a significant association between these two variables (ϱ = -.238). Using public transportation to get groceries was also associated with whether the respondent could consistently afford a healthy meal in both Spearman correlation (ϱ = .314) and chi-square analyses (χ2 = 9.570; p = .002). Household composition, specifically the number of children in the household, was significantly associated with whether the participant could consistently afford a healthy meal using Spearman correlation analysis (ϱ = -.372).

Barriers to Affordability

Participants defined healthy foods across six themes: food categories (n = 53), food to avoid or eat moderately (n = 34), production practices (n = 32), consumption practices (n = 29), and nutrients (n = 19). Food categories were the most frequently cited theme with participants most commonly referring to fruits and vegetables (n = 52), meat (n = 14), and grains (n = 8). The most cited foods to avoid or eat moderately were sugar (n = 10), additives (n = 7), and meats (n = 7). Examples of production practices included fresh (n = 20), unprocessed (n = 8), and organic foods (n = 7). Almost half of respondents (48%) reported that they could not consistently afford to prepare a healthy meal. Variables that were associated with the ability to afford healthy meals were examined for inclusion in the logistic regression. Whether an individual was ever unable to afford a healthy meal was significantly associated with worry about running out of food in both Spearman correlation (ϱ = .448) and chi-square analyses (χ^2 = 19.079; p = .001). Having to avoid a preferred store for any reason was also associated with whether an individual was ever unable to afford a healthy meal in both Spearman correlation (ϱ = .284) and chi-square analyses (χ^2 = 7.723; p = .005). Spearman correlation analyses found significant associations between the use of both SNAP (ϱ = .280) and WIC (ϱ = -.354) and those who were unable to afford a healthy meal. Chi-square analyses were conducted using binarized variables for SNAP (0 = no, 1 = yes in the past year) and WIC (0 = no, 1 = yes in the past year). Both analyses were statistically significant (SNAP: χ^2 = 11.739, p = .003; WIC: χ^2 = 11.309, p = .004).

Predictors for the logistic regression model were selected based on a bivariate analysis, whereby variables demonstrating a statistically significance ($p < .05$) were considered for inclusion in the logistic model. Variables were then iteratively added and removed based on changes in overall model fit. The final binary logistic regression model is presented in Table 3. The strongest predictors of the ability to afford a healthy meal were worry about running out of food (OR = 0.181, 95% CI [0.058, 0.561]), ever avoiding a preferred store for any reason (OR = 0.177, 95% CI [0.049, 0.641]). The model indicated that worry about running out of food, ever having to avoid their preferred store, and using SNAP assistance, are significant predictors of the ability to consistently afford a healthy meal (alpha value of .05).

Survey data also provided additional information on what made it difficult to afford healthy meals. Specifically, in the open-ended questions, respondents described several barriers to the preparation of healthy meals, including the cost of healthy food and available income (n = 34), food

Table 3. Binary Logistic Regression Results

Predictors	Coefficient	Standard Error	Wald	df	*p*-value	Odds Ratio	95% CI Lower	95% CI Upper
Worry about running out of food	–1.709	0.577	8.772	1	0.003	0.181*	0.058	0.561
Having to avoid a preferred store	–1.730	0.656	6.954	1	0.008	0.177*	0.049	0.641
SNAP assistance	-0.664	0.337	3.882	1	0.049	0.515*	0.266	0.997
Public transportation use	0.255	0.860	0.088	1	0.767	1.291	0.239	6.964
Age	0.021	0.019	1.282	1	0.258	1.022	0.984	1.060
Constant	1.593	1.450	1.206	1	0.272	4.918		

* Indicates statistically significant results at .05 level.

access and availability (n = 30), lack of interest or motivation (n = 21), and lack of time (n = 19).

While survey results highlight individual barriers to healthy diets, the focus group data presented below offer a community perspective on the food environment and how it shapes food insecurity and healthy food access, while also providing additional context on affordability challenges.

Insights from Focus Group Data

Two major themes related to participants' lived experience with food access emerged from the qualitative data. The themes included "navigating the food apartheid environment" and "community food solutions."

Theme 1: Navigating the Food Apartheid Environment

Under this theme, participants described interconnected structural and individual challenges that characterize the food environment. These include the cost of transportation and other household financial obligations. They also identified institutional disinvestment in their community and limited physical access to grocery stores as additional barriers to the access and affordability of healthy foods.

Participants described making trade-offs between purchasing food and meeting other necessities, including medication, transportation, and household expenses: "What makes it worse is having to choose between food and blood pressure medicine, food and medication, food and transportation. So, it's always, what's more important?" (Focus Group 1 participant). One participant explained that having to choose between food and transportation often led individuals to make less healthy food choices: "You gotta get on two buses to get over there [to a popular grocery store], are you going to go? No. You're going to go to McDonald's and get that two-for-three and call it a day" (Focus Group 2 participant).

Participants felt that their community was overlooked or neglected by the local government and private sectors. They suggested increasing access to healthy foods by building more grocery stores could improve healthy food access; however there was little to no incentive for the city or retailers to invest in their communities:

> I know, a lot of times we hear the City and the County: "Don't nobody want to put a grocery store over there. They don't want to do it. They don't want to invest. … Look. The City and the County do a lot of things with private funds, okay? So, they do what they gotta do to get what needs to be done to be beneficial for them. (Focus Group 1 participant)

Focus group participants discussed two defining features of their food environment: limited accessibility and persistent food insecurity. Limited access to grocery stores due to distance or lack of reliable transportation created additional concerns for families and vulnerable individuals in their community who would have relied on these families to access food. This situation as illustrated below weakens community solidarity:

> Because of accessibility, families are more worried about how they're going to get to the store than how they're going to get Ms. Ethel her groceries also. So, it creates a whole host of problems. It's like a domino effect. Things that you could be doing, but because of accessibility, everyone has to think about themselves and their families. And Ms. Ethel sure can't get to the store. You understand? So, it creates a whole host of problems. (Focus Group 1 participant)

These discussions revealed that participants understood food insecurity as fundamentally tied to a structural problem of the food environment, particularly the type of foods that were available:

> Oh sure, so when I think of food insecurity, I think of the accessibility of healthy affordable food, and so I believe. I don't want to call this area a food desert; I think that might be inaccurate, because there are farms over here, but this is definitely a food insecure area, because after a certain hour, you're not going to be able to get anything except deep fried junk that you're going to eat, tastes good, and then your stomach is going to be hurting within the next hour after eating it. (Focus Group 2 participant)

Additionally, they also commented on the disparity in access to different food choices between the east and west sides of Gainesville. The disparity in access to healthy food is described as food apartheid, as illustrated in the following quote:

> I don't say food desert, I say food apartheid. Because that's exactly what it is. So, then, that creates food insecurity. … If I don't live close to a grocery store where I can get three for $10, and the only thing that's around me are dollar stores and convenience stores and I have to go buy that one item for $5, then that's creating food insecurity for me because I live somewhere where there's food apartheid going on. (Focus Group 1 participant)

Theme 2: Community Food Solutions

The focus groups actively engaged participants to explore solutions they have used successfully, as well as additional strategies that could help build a community free of food insecurity. Participants in the earlier focus groups focused their suggestions more on local grocery stores, healthier options in convenience stores, or smaller produce markets in the neighborhood. For example, one participant said:

> I went to Tallahassee one weekend, and I ran into one of those co-op stores that was built right in the middle of a marginalized community. He had food, he had drinks, he had candy, they had cooking on site for the community to come in and get the things that they need. (Focus Group 1 participant)

Other key recommendations, particularly from the third focus group, included educational programs for children (e.g., gardening), offering cooking classes for adults and children, and developing educational programs (e.g., nutrition, gardening) that emphasized experiential learning through real life examples, community testimonials, and opportunities to experience the benefits, as illustrated in the following example:

> If I see someone who is heavier and I know that person right here in Gainesville. … And in three months to whatever, they're talking about, "We started in December, and six months later in June, we're living a healthier life, I'm happier, I'm stronger, I can do this with my child. We're in this program." If I can see it and I know that person … even if I don't know that person, they're still right here in my community, it kinda hits home. And maybe that person cannot just be a person who does it, but they can be an ambassador, and they can help in that garden, and because being that they're in my area, they know my lingo, they know how hard I work, they know I'm a single parent, they know what it's like because they were that person. And they did it, and I literally can see, "Okay, you did it; I can do it too." (Focus Group 3 participant)

However, a few participants observed that food-related programs in their communities were unsustainable. They believed that certain resources, such as community gardens, were underutilized:

> What's the library down the street's name? [trying out possible names] They have a community garden, but I never really see anyone using it, so maybe there's just not enough people knowing about it. [another participant suggests the Cone Branch] Yes. With the track in the back. That's it. Yeah, there's a community garden there. I've never seen anyone actually out there. So maybe it's just people just not knowing about it. (Focus Group 3 participant)

These qualitative results reveal the difficulties of navigating a food apartheid environment that forces households to overcome multiple barriers in order to access healthy foods. Individual factors such as lack of transportation, special diets, or the cost of medication further increased the barriers to healthy foods. Participants saw a lack of institutional support for healthy food access. In response to these structural barriers, participants emphasized the need for programs that were practical, sustainable, and tailored to their needs.

Discussion

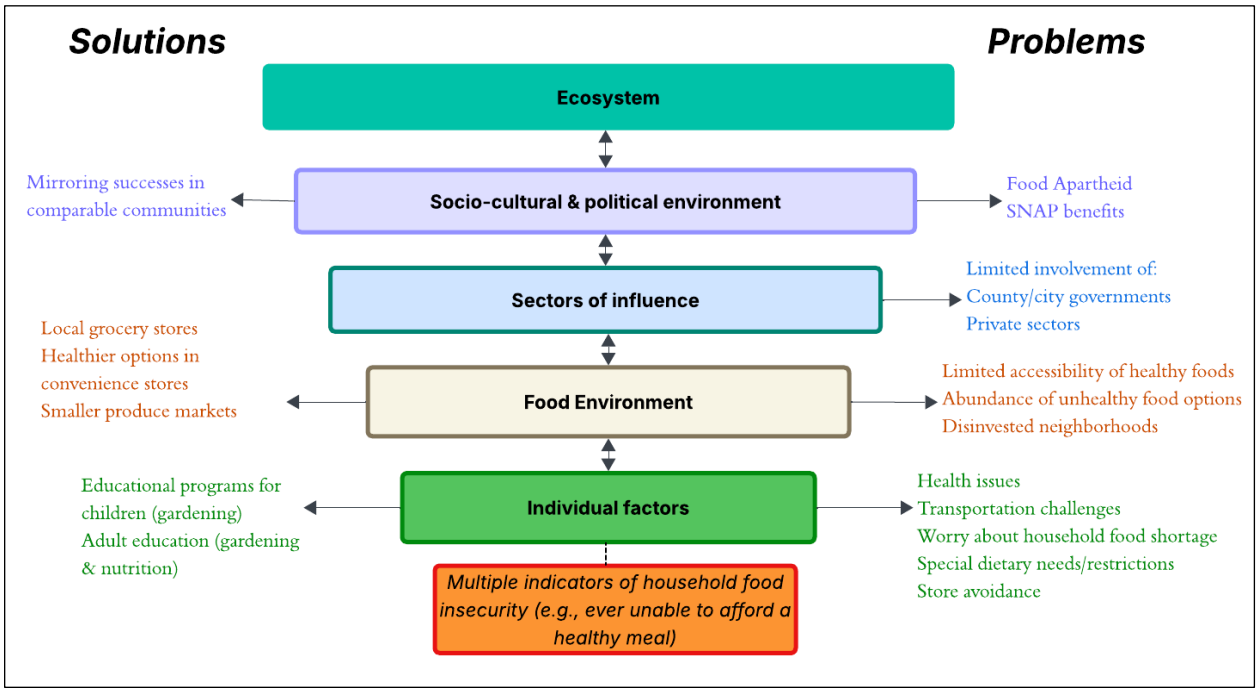
While there is extensive literature describing the food environment of low-income communities (Black et al., 2014; Caspi et al., 2012; Cooksey-Stowers et al., 2017; Gittelsohn et al., 2008; Karpyn et al., 2020), there are fewer studies that have used CBPR to understand the perceptions of those who navigate this environment (Rollins et al., 2021; Shisler et al., 2023). In this study, we engaged members of a CAB to explore residents' perceptions of their food environment and the challenges they face in securing a healthy diet.

Our results demonstrate that community engagement is critical for understanding food systems disparities. The forward-looking, empowerment-focused, and community needs-centered nature of CBPR (Ortega et al., 2018; Riccardi et al., 2023) helped us to better understand the lived realities of communities affected by food insecurity. One key insight was suggested by the CAB and it captured the consistency of affording a healthy meal. This was a key indicator through which food insecurity was understood and felt by community members. Our results are grounded in the practical and daily struggles of accessing nutritious foods in a food apartheid environment. These results have yielded insights that both align and extend the existing literature that use other measures of food insecurity.

A key finding of this study is the relationships between the ability to consistently purchase healthy meals, individual factors, the food environment, and sectors of influence (Figure 3). Prior research has largely examined these constructs and found significant associations between healthy eating and household challenges, neighborhood food availability (Karpyn et al., 2020; Zorbas et al., 2018), and access to a private vehicle (Wright et al., 2016). Our results strengthen this body of work by suggesting that these same factors also operate upstream, shaping whether individuals can afford healthy meals. Also notable is the inverse relationship found between SNAP benefits and the ability to afford a healthy meal, corroborating evidence from Alawode et al. (2023), Rivera et al. (2019), and Verghese et al. (2019), that SNAP may be falling short in reducing food and nutrition insecurity.

Beyond affordability, participants saw deeper structural issues rooted in policy decisions, disinvestment, and structural racism, which are common in Black and Brown communities (Gripper et al., 2022). Researchers commonly refer to these experiences as food apartheid (de Souza, 2024; Gripper et al., 2022). The intersection of racially patterned food environments and individual factors, such as health and transportation challenges, makes accessing healthy diets even more challenging. This was evident among focus group participants who discussed the tradeoffs some individuals must make between food, medicine, and transportation. Additionally, adhering to dietary restrictions in food swamps may be especially challenging for individuals with chronic illnesses, as evidenced in the survey data. The challenges of maintaining medically recommended diets in food swamp environments create a double burden for Black communities, who are 38% more likely to live in such environments (Cooksey-Stowers et al., 2017), 73%

Figure 3. Summary of Participants Lived Experience with Food Insecurity in the Socioecological Model of Food Systems



more likely to have diabetes (Cheng et al., 2019), and 44% more likely to have hypertension than white people (Aggarwal et al., 2021).

While studies have shown that food and nutrition indicators together are far more effective than food security markers alone (Mozaffarian et al., 2021; Simelane & Worth, 2020), this study demonstrates that centering community knowledge can uncover lived experiences with food and nutrition insecurity. Finally, the solutions proposed by participants (such as community gardening) align with those Gripper et al. (2022) found common in communities affected by food apartheid. Solutions such as increasing the availability of grocery stores and healthier options in convenience stores already have existing implementation mechanisms, such as the Healthy Food Financing Initiative. Therefore, leveraging existing policies, while addressing their limitations, represents a critical opportunity to translate community knowledge into equitable food systems change.

This study has several limitations. Validated measurements of healthy eating and FNS outcomes (e.g., Healthy Eating Index, FNS Index), were not included in the instrument design. As a result, this limits the extent to which our results are comparable to previous findings and constructs of FNS and healthy eating. Our sampling design was also another limitation. Data collection was limited to nine purposively and conveniently selected neighborhoods in Southeast Gainesville; therefore, the results presented here may have been different if a probability sampling design had been used. The modest survey sample size (N = 103) also represents a limitation; however, the study's focus on a population that is relatively homogenous in key characteristics helped to capture meaningful associations and patterns within this sample. Although this study achieved a substantial level of community involvement, CBPR requires significant time and resources. As a result, conducting a CBPR project within an academic setting can make it difficult to fully realize community-led engagement. In addition, CAB involvement in data analysis and dissemination was limited, even though the findings were later shared with community stakeholders through a lay report (see Grace Grows, n.d.). Despite these limitations, a key strength of the study remains the CBPR approach as it revealed details that are important to those experiencing

food insecurity in their neighborhoods and households. Additionally, this study took place during the COVID-19 pandemic, thus participants' experiences provide valuable insights of food access during a time of widespread disruption.

Conclusion

The involvement of a CAB represents a substantive contribution to this study and a valuable learning experience for researchers seeking to implement a CBPR. Their involvement in the design and implementation of the project deepened our understanding of residents' barriers to healthy diets and their lived experiences with food apartheid. Thus, the implications of food apartheid are concerning because they often reflect multiple layers of structural issues that a single intervention cannot resolve. While participants suggested that disparities in their food systems could be reduced through interventions that are viable, sustainable, and directly address community needs, we also identify a lack of local institutional support. This gap suggests that community-driven solutions, while useful, may be difficult to sustain without relevant and supportive policies that prioritize equitable food access from city and county governments.

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Appendices

Appendix A. Survey

Food Access

1. **This question is going to ask you about where you went food shopping in the last month.**
   a. In the last month, where did you shop for food MOST OFTEN? This could be a farmer's market, grocery store, dollar store, etc.)
      a. How many times did you shop there in the last month?
      b. What do you like about shopping there?
      c. Have you ever avoided shopping there because it was too difficult?
      d. If so, what made it too difficult?
   b. In the last month, where did you shop for food SECOND MOST OFTEN? This could be a farmer's market, grocery store, dollar store, etc.)
      a. How many times did you shop there in the last month?
      b. What do you like about shopping there?
      c. Have you ever avoided shopping there because it was too difficult?
      d. If so, what made it too difficult?
   c. In the last month, where did you shop for food THIRD MOST OFTEN? This could be a farmer's market, grocery store, dollar store, etc.)
      a. How many times did you shop there in the last month?
      b. What do you like about shopping there?
      c. Have you ever avoided shopping there because it was too difficult?
      d. If so, what made it too difficult?

2. **How often do you use public transportation to get groceries?**
   - Always
   - Often
   - Sometimes
   - Occasionally
   - Never

3. **How often do your neighbors ask you for help getting to the store or picking up groceries for THEIR households?**
   - Never
   - Once a month
   - A few times a month
   - Once a week
   - More than once a week

4. **How often do you need to ask friends, family or neighbors for help getting to the store or picking up groceries for YOUR household?**
   - Never
   - Once a month
   - A few times a month
   - Once a week
   - More than once a week

5. **In a typical year (prior to COVID-19), how often did you worry that your household would run out of food?**
   - Often
   - Sometimes
   - Occasionally

- Never
- Don't know/don't want to respond

Healthy Meals

6. In a few words, please describe what "healthy food" means to you.

7. Based on your description of "healthy food," how healthy is your diet?
   a. I only eat healthy food
   b. I mostly eat healthy food
   c. I sometimes eat healthy food
   d. I occasionally eat healthy food
   e. I never eat healthy food
   f. Don't know / don't want to respond

8. In a typical year (prior to COVID-19), how often was there a time that you could not afford to prepare a healthy meal?
   - Often
   - Sometimes
   - Occasionally
   - Never
   - Don't know/don't want to respond

9. What are some of the reasons / challenges that prevent you from preparing meals that you would consider "healthy"?

10. In what ways do you see a person's diet impacting their overall health?

Food Waste

11. How often do you have issues with refrigeration or with storing food?
   - Never
   - Occasionally
   - Sometimes
   - Frequently
   - Don't know/don't want to respond

Special Diets

12. Does anyone in your household have any special dietary needs?
   - Yes
   - No
   - Don't know/don't want to respond

13. (If yes to #12) Can you please describe the special dietary needs of your household?

14. (If yes to #13) In the past month, how often did you have difficulties with buying or preparing foods that fit within your household's special dietary needs?
   - Often
   - Sometimes
   - Occasionally
   - Never
   - Don't know/don't want to respond

Community Gardens

15. **How interested or not interested are you in fruit and vegetable gardening at home or at a community garden?**
    - Very interested
    - Somewhat interested
    - Neither interested nor uninterested
    - Not at all interested
    - I'm not sure

16. **Would you be interested in receiving training in fruit and vegetable gardening?**
    - Yes
    - No
    - I'm not sure

17. **How likely or unlikely are you to put your children into a gardening program?**
    - Very likely
    - Somewhat likely
    - Neither likely nor unlikely
    - Somewhat unlikely
    - Very unlikely
    - I'm not sure
    - This question does not apply to me

18. **Please tell us where there are gardens in the SE Gainesville area that offer food to community members, such as Community Gardens, Church Gardens, etc.?**

Food Assistance Programs

19. **In the past year, how often has your household used each of these programs?**

	Never	1-2 times	3-4 times	5 or more times	Don't know or don't want to respond
Food pantries	○	○	○	○	○
Food distribution from a church	○	○	○	○	○
Food distribution from another organization	○	○	○	○	○
Student free meals	○	○	○	○	○
Weekend Food Backpacks or other food backpack program	○	○	○	○	○
WIC	○	○	○	○	○
SNAP	○	○	○	○	○
Fresh Access Bucks	○	○	○	○	○

20. **If you have received food from a food assistance program or pantry, how often does the food fit your household's dietary needs?**
    - Almost always
    - Often
    - Sometimes
    - Occasionally
    - Never
    - Don't know/don't want to respond
    - Not applicable

21. **If you have received food from a food assistance program or pantry, how satisfied are you with the quality of the food you received?**
    - Completely satisfied
    - Somewhat satisfied
    - Neither satisfied nor dissatisfied
    - Somewhat dissatisfied
    - Completely dissatisfied
    - Don't know/don't want to respond
    - Not applicable

22. **If you receive food assistance (such as food stamps), how often does the food you get cover you for the month?**
    - Almost always
    - Often
    - Sometimes
    - Occasionally
    - Never
    - Don't know/don't want to respond
    - Not applicable

Community Assets

23. **What are three ideas you have for improving access to healthy food in your community?**

24. **Of the three ideas you listed previously, what skills, knowledge, or other resources could you provide to make sure one of these ideas is successful?**

25. **What do the residents value about your neighborhood?**

26. **Please list any groups or organizations in which you participate (for example, churches, non-profit organizations, hobby and special interest groups, etc.).**

27. **In what ways do you stay involved with your community?**

Demographics

28. **What is your age?**

29. **How do you identify your gender?**
    - Man
    - Non-binary
    - Woman
    - Prefer to self-describe:
    - Prefer not to respond

30. **What category(ies) best describes you? Feel free to select more than one if applicable.**
    - American Indian or Native American
    - Asian
    - Native Hawaiian or other Pacific Islander
    - Black or African American
    - White
    - Other:

31. **Are you Hispanic or Latinx?**
    - Yes
    - No

32. **What is your highest level of education?**
    - No formal education
    - Some high school
    - High school diploma or the equivalent (GED)
    - Some college (no degree)
    - Trade/technical/vocational training
    - Associate degree
    - Bachelor's degree
    - Master's degree
    - Doctorate degree
    - Professional degree
    - Other:
    - Prefer not to respond

33. **What is your zip code?**

34. **How many adults live in your household (including yourself)?**

35. **How many children (17 years old or younger) live in your household?**

Appendix B. Focus Group Discussions

Questionnaire of focus groups held in February

1. Please describe any challenges you encounter with using public transportation for food.
2. What is the one most important thing that people need to know about households that worry about food running out?
3. What is the single most important thing we can do to help those households facing food insecurity?
4. In what ways do you see your or your neighbor's diets leading to health issues?
5. What do you think is the one most important thing your community needs to know about food and health?
6. How do you solve any challenges you face with buying or preparing foods that fit within your household's special dietary needs?
7. What could be done to make it easier to meet your household's special dietary needs?
8. If you have used food pantries, food distributions, student free meals, weekend food backpacks, WIC, SNAP, Fresh Access Bucks, or any other food assistance program, how useful or not useful do you find them?
9. If you have used food pantries, food distributions, student free meals, weekend food backpacks, WIC, SNAP, Fresh Access Bucks, or any other food assistance program, please provide any suggestions you have for improving the program(s).
10. What effect has the COVID-19 pandemic had on your diet and access to food?
11. As a result of the pandemic, what solutions have you found to help your family or your community to eat?

Questionnaire of focus group held in November

1. What do you see that's special about your community?
2. Think back to the survey you took and the ideas you provided for solutions to address food access. Considering the solutions you gave, how do we make those ideas a reality?
    a. PROBE: Some of the most common things mentioned were a grocery store in the Southeast, community gardening, and educational programs.
3. IF NOT COVERED: In the survey, participants indicated that education is another important priority to help improve healthy food eating in the community. In your opinion, what kind of educational programs can actually be useful and keep people engaged?
    a. IF NEEDED: For example, cooking demonstrations at grocery stores, providing recipes, etc.
    b. PROBE: What topics could the community benefit from learning about?
    c. PROBE: How should the information be shared? For example, online, in person, etc.?
4. What barriers do you see to having gardens as one solution to food access issues in Southeast Gainesville?
5. In the survey we asked you to describe what healthy eating means to you. Can you talk more about what you shared?
6. What can be done to ensure healthy eating is easy for people with any life circumstance or personal interest?
7. What are some of the things that already exist in your community that help give people access to foods they want?
    a. IF NEEDED: For example, this could be something like a neighbor who is great at cooking or fishing, people who share or trade foods, community gardens, food distribution from a church, etc.
    b. What type of support do these programs or services need to continue operating or expand?
    c. How can you and your neighbors use these resources to improve food access in your community?
8. Imagine that five years from now, no one in the Southeast Gainesville community has to worry about running out of food and everyone has access to the foods they want. Is there anything else that we haven't discussed that could make this a reality?

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Indigenous vegetables and household food security in a borderland community: Evidence from the Dayak Bidayuh of Entikong, Indonesia

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Abstract

Indigenous vegetables play a critical yet under-documented role in household food security among borderland communities in Borneo. This study examines how Dayak Bidayuh households in Entikong, Indonesia, integrate wild and cultivated plant foods into daily diets, cultural practices, and adaptive livelihood strategies within a rapidly modernizing Indonesia–Malaysia border economy. These transformations have been accentuated by recent disruptions, including the COVID-19 pandemic, the rise of commercial agriculture, and the proliferation of fast food and processed goods, which increasingly alter traditional foraging,

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cooking, and eating habits among younger generations.

Using a multi-site qualitative design supported by household interviews, participant observation, ambulatory foraging walks, and nutritional analysis, data were collected from 30 respondents across five villages reflecting varying degrees of market exposure and ecological access, as well as variation in gender related to age, occupation, or professional roles that spoke to food heritage and production.

Findings reveal five interrelated dynamics: hybrid subsistence and cash-based dependency, dietary transitions linked to Malaysian border markets, persistent cultural significance of indigenous dishes, erosion of ecological knowledge across generations, and gendered constraints in food provisioning. Despite increasing reliance on commercial foods, dishes such as *sayur rampai*, *ayam pansuh*, and *pekasam* remain essential to cultural identity, ecological memory, and social cohesion. The resulting Bidayuh Food Heritage and Food System Model highlights how access to land, knowledge transmission, ritual identity, and market dynamics collectively shape food security outcomes. Strengthening indigenous vegetables and cultural foodways offers a pathway for enhancing dietary diversity, cultural resilience, and locally grounded food sovereignty in borderland contexts.

Keywords
indigenous vegetables, Dayak Bidayuh, borderland food systems, food sovereignty, traditional ecological knowledge, household food security

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Conflict of Interest Disclosure
The authors declare that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Introduction
Indigenous food systems are increasingly recognized as critical for sustaining food security, health, and cultural continuity among rural and frontier communities globally. Traditional food systems, defined as locally sourced and culturally embedded food practices, often encompass a diverse array of wild and cultivated plant foods managed through time-tested ecological knowledge and social norms (Kuhnlein et al., 2013; Sustainable Food Systems, 2022). At the same time, contemporary food systems across Southeast Asia face increasing inefficiencies along agricultural value chains. Post-harvest stages alone may account for up to 75% of total food value-chain costs, and food losses in Indonesia have been estimated at approximately 20% of total agricultural production (Garrity et al., 2024).

The border region of West Kalimantan is characterized by considerable ethnic diversity, and the persistence or transformation of Indigenous food practices is shaped less by ethnic identity than by structural factors within the local food system. In particular, land access, intergenerational transmission of ecological knowledge, and increasing exposure to cross-border market foods play decisive roles in shaping household food practices in the Entikong borderland. These dynamics highlight how Indigenous food systems are embedded within broader socioeconomic and territorial conditions rather than functioning solely as expressions of cultural identity.

Indigenous food systems and traditional ecological knowledge are increasingly recognized as important contributors to global sustainability agendas, including several Sustainable Development Goals related to food security, biodiversity conservation, and sustainable resource management (Nepal, 2025). Recent studies from the Asia-Pacific region have highlighted the need for collective action to preserve Indigenous food systems and to advocate for traditional food production through integrated approaches to food security, biodiversity conservation, and cultural heritage preservation. Indigenous food practices, such as harvesting traditional crops using nondestructive methods and utilizing knowledge and skills passed down through generations, have been shown by

scholars to be key components in sustaining resilient local systems of food production, nourishment, and ecological sustainability.

Across the Asia-Pacific region, scholars and practitioners have increasingly emphasized the importance of collective action to preserve Indigenous food systems and support traditional food production. These efforts often link food security, biodiversity conservation, and cultural heritage preservation. Indigenous food practices, such as harvesting traditional crops using nondestructive techniques and applying ecological knowledge transmitted across generations, play an essential role in sustaining resilient food systems, supporting ecological sustainability, and maintaining culturally meaningful diets.

Regional initiatives have therefore sought to strengthen traditional food production, expand market access for indigenous crops, and recover local ecological knowledge in response to pressures from modernization and dietary transitions. Such approaches highlight the importance of integrating community participation, supportive policy frameworks, and Indigenous knowledge in food governance. At the same time, regional analyses point to emerging challenges, including agricultural commercialization, forest loss, and changing consumption patterns, that threaten the continuity of traditional food practices and the intergenerational transmission of ecological knowledge.

These dynamics also highlight the need for empirical research that documents Indigenous food practices and explores how communities modify them in response to socioeconomic transformation. Research on Indigenous food systems can therefore usefully contribute to current debates about culturally appropriate and ecologically sustainable food strategies across Asia and the Pacific by positioning local case studies in a wider regional discussion.

Within this broader context, indigenous food sovereignty has increasingly been framed not only in terms of access to sufficient and nutritious food but also in communities' capacity to govern their food systems, protect customary knowledge, and maintain cultural identity amid environmental change and market integration (Sustainable Food Systems, 2022; World Bank, 2024). Yet the specific contributions of indigenous plant foods to household food security in borderland contexts such as the Indonesia–Malaysia frontier remain insufficiently explored.

Wild edible plants and indigenous vegetables are increasingly highlighted as nutrient-dense resources that enhance dietary diversity and strengthen resilience in local food systems. Evidence from studies in Asia and Africa suggests that wild and semidomesticated vegetables can significantly contribute to macro- and micronutrient intakes, particularly among low-income households facing periodic food shortages (Casas, 2024; Food and Agriculture Organization of the United Nations [FAO] et al., 2021; Hunter et al., 2021). Empirical work has also demonstrated that these plant foods serve as critical safety nets during economic and ecological shocks by supplementing staple foods and mitigating seasonal scarcity (Bliss et al., 2025; Kumar et al., 2025). Research on indigenous vegetables in Southeast Asia suggests that household production and use of these species may support both nutrition and livelihoods when integrated with culturally appropriate management practices (Hoang, 2025). However, most existing work in this region focuses on individual dimensions, such as nutrient composition or production systems, without simultaneously linking diversity, consumption patterns, and cultural perceptions within community food systems.

Household food insecurity and low dietary diversity persist as major challenges in rural Indonesia, where geographic remoteness, volatile food prices, and precarious livelihoods exacerbate vulnerability among smallholder households (Puspitasari et al., 2024; World Bank, 2024). Although Indonesia is classified as an upper-middle-income country, reflecting decades of economic growth and structural transformation, substantial regional inequalities in livelihoods and food access persist, particularly in frontier and rural borderland regions (Halimatussadiah et al., 2024). Studies conducted in Indonesian border areas indicate that limited market access, cross-border price asymmetries, and unstable supply chains increase household dependence on purchased foods, often with negative implications for dietary quality (Ariningsih et al., 2024).

At the same time, local natural resource use, especially the consumption of wild edible plants and indigenous vegetables, continues to play an important but underdocumented role in household diets in borderland settings. Research synthesizing food practices in frontier communities highlights the role of plant food knowledge transmitted through gendered and intergenerational networks (Sulaiman et al., 2024), yet robust quantitative data linking these practices to food security outcomes remain scarce. Studies from other contexts demonstrate that foraging practices persist even in urban environments. For instance, more than half of respondents engaged in foraging across multiple urban blue spaces in India, illustrating the continuing nutritional, cultural, and livelihood significance of these practices even in highly urbanized landscapes (Basu et al., 2025).

The Dayak communities of Borneo are widely recognized for their extensive ecological knowledge and diverse use of plant resources. However, most existing research has concentrated on shifting cultivation systems, staple crop production, or medicinal plant use rather than on indigenous vegetables and their contributions to household diets (Caviedes et al., 2024). Ethnographic research on Bidayuh culinary traditions in neighboring Sarawak highlights the cultural importance of locally foraged and cultivated plants in everyday meals and ritual contexts (Sageng et al., 2024), suggesting a rich but insufficiently documented diversity of edible species across the Indonesia–Malaysia border.

Civil society initiatives have also begun documenting traditional Dayak recipes and farming knowledge, reflecting growing interest in safeguarding Indigenous culinary heritage (Slow Food, 2025; Terralingua, 2024). These efforts are important for cultural preservation, and systematic academic research remains necessary to better understand the socioecological dynamics shaping these food systems. In particular, a significant gap persists in empirical studies that quantitatively link plant species diversity, consumption frequency, and nutritional contribution of indigenous vegetables to household food security outcomes among Dayak Bidayuh communities in Indonesian border regions.

In addition to their dietary importance, Dayak food traditions are closely intertwined with Indigenous knowledge of medicinal plants. Ethnobotanical studies have documented dozens of species used for therapeutic purposes, commonly prepared through boiling, infusion, or grinding of leaves, rhizomes, and roots (Haeruddin et al., 2017). This knowledge, transmitted across generations, reflects deep connections between forest biodiversity and Indigenous health systems in Borneo (Az-Zahra et al., 2021; Luardini et al., 2019; Qamariah et al., 2020). Historically, many indigenous Bornean communities have combined forest foraging, small-scale cultivation, and locally gathered food plants to meet household dietary needs. Indigenous livelihoods in the interior regions of Borneo have long depended on diverse forest resources, including hunting, fishing, and collecting of forest products for subsistence and trade (Jessup & Vayda, 1988). These practices not only provide nutritional diversity but also reinforce cultural identities linked to local landscapes and ecological knowledge (Murhaini & Achmadi, 2021). Even amid market integration and modernization, traditional diets remain closely connected to forest biodiversity, as documented in contemporary ethnographic and ecological studies.

To address these gaps, we examined how indigenous vegetables used by Dayak Bidayuh households in Entikong, West Kalimantan, contribute to household food security by integrating species inventories, consumption patterns, nutrient profiles, and community perspectives on access, cultural meaning, and change over time.

Beyond its cultural and ecological dimensions, the Bidayuh food system represents a localized model of borderland food provisioning that intersects with household nutrition, informal trade, and cross-border market dynamics. In this context, indigenous vegetables function not only as cultural foods but also as practical components of a community-based food economy shaped by land access, seasonality, and shifting dietary preferences. Understanding these dynamics offers practical insights for food system practitioners concerned with nutrition-sensitive agriculture, local food market development, and biodiversity-based food strategies.

This study documents Indigenous foraging, cultivation, and culinary practices within the Dayak Bidayuh community of Entikong, a borderland region where traditional food systems coexist with expanding market forces. Using household interviews, participant observation, foraging walks, and nutritional analysis, we investigated how knowledge of forest foods, farming practices, and culinary preparation has been maintained across generations. Particular attention was given to generational perspectives, as younger participants reveal emerging shifts in crop utilization, food preparation, and dietary preferences associated with modernization and livelihood diversification. By situating these practices within a broader socioeconomic context, the study provides empirical evidence for discussions on rural food system development and highlights the importance of documenting and supporting Indigenous food practices to sustain cultural heritage and local food security in borderland communities.

This case study, therefore, offers empirical insights that can inform policy initiatives and applied programs aimed at strengthening rural food systems, particularly in marginalized and borderland regions.

Dayak Bidayuh Identity

Among the Indigenous peoples of Borneo, the Dayak Bidayuh are a culturally and ecologically distinct group living primarily along the borderlands of West Kalimantan (Indonesia) and Sarawak (Malaysia). The term "Bidayuh," derived from the root *bi* ("land") and *dayuh* ("people"), historically referred to upland swidden cultivators whose lifeways were closely tied to forest mosaics, riverine systems, and shifting cultivation landscapes (Azmi et al., 2017; Seran & Mardawani, 2020). Unlike externally imposed ethnic categories, Bidayuh social identity has traditionally been rooted in microterritorial affiliation to particular *kampung* (villages) and river valleys rather than a singular pan-Bidayuh construct, leading to a rich tapestry of dialects, customs, and resource regimes within what outsiders label a single ethnolinguistic group (Azmi et al., 2017; Chua, 2009). In the Indonesian context, Dayak Bidayuh communities are often subsumed under broader "Dayak" classifications in census and development planning, a framing that obscures localized ecological knowledge and adaptive strategies embedded within borderland social systems (Chua, 2009; Pawi & Ungang, 2021).

Ecological knowledge and subsistence practices among the Dayak Bidayuh are deeply intertwined with sociocultural norms governing land use, seasonal mobility, and the management of plant resources. Traditional subsistence is characterized by shifting cultivation, rotational gardening, and diversified foraging strategies, which create spatial and temporal niches for a wide variety of edible plants, including leafy vegetables, tubers, and wild greens (Kumar et al., 2025; Sageng et al., 2024). This knowledge system extends beyond mere utility, encompassing the classification of species by ecological indicators, seasons, and sensory attributes. The system is transmitted through kinship networks and ritual calendars, making plant foods symbols of identity and continuity (Kumar et al., 2025; Sada et al., 2019). Such embedded practices are not static; they mediate the community's relationship with forest landscapes and serve as a cushion against seasonal scarcity and socioeconomic change.

The socioeconomic landscape of Bidayuh borderland communities has become increasingly hybridized due to market integration, cross-border mobility, and infrastructural development. Economic ties with Malaysian markets shape dietary patterns through access to commercially processed foods and wage labor, even as local plant foods remain central to household diets and cultural events (Kumar et al., 2025; Murhani, 2021). This dual economy, part market-oriented, part subsistence-based, generates both opportunities and tensions for Dayak Bidayuh families, influencing their food choices, the transmission of generational knowledge, and their resilience (Ting et al, 2017). Younger generations, exposed to formal schooling and external labor markets, are less engaged in traditional gardening and foraging, posing risks to the continuity of ecological knowledge that underpins Indigenous food systems (Murhaini & Achmadi, 2021).

Despite these pressures, many Dayak Bidayuh households in West Kalimantan actively maintain Indigenous food practices as a means of cultural

affirmation and nutritional sustenance. Locally harvested vegetables, leafy greens, and wild edible plants are not merely fallback options during lean seasons but are instead integrated into daily meals and ceremonial feasts, reinforcing a sense of belonging and ecological attachment (Kumar et al., 2025; Pawi, 2021; Sageng et al., 2024). Understanding Dayak Bidayuh food systems thus requires attention to the intersection of identity, territory, and ecological knowledge in a borderland context where state classifications, market forces, and cultural resilience coalesce. This ethnographic grounding provides critical context for examining how indigenous vegetables, and the knowledge systems that sustain them, contribute to household food security in Entikong and similar frontier settings.

Applied Research Methods

This research was grounded in ethical engagement and collaborative knowledge production with Dayak Bidayuh households in the borderland region of Entikong, West Kalimantan. West Kalimantan is located on the island of Borneo in western Indonesia and shares a land border with the Malaysian state of Sarawak; the province's location within Indonesia is shown in Figure 1. Figures 2 and 3 show the study area in Entikong Subdistrict. West Kalimantan is one of the most ethnically diverse provinces in Indonesia, with populations including Dayak, Malay, Javanese, Chinese, and several other ethnic groups (Ananta et al., 2015). This broader diversity characterizes the regional demographic landscape, but the present study focused specifically on Dayak Bidayuh households in the Entikong borderland community.

The research was conducted in five villages in Entikong Subdistrict, Sanggau District, West Kalimantan, a border region adjacent to Sarawak, Malaysia. Entikong Subdistrict has an estimated population of approximately 20,334 residents distributed across several rural villages characterized by smallholder farming, cross-border trade, and forest-based livelihoods (Badan Pusat Statistik Kabupaten Sanggau, 2023).

The study contributes to emerging work on indigenous food systems by centering Bidayuh knowledge, practices, and aspirations regarding indigenous vegetables and their role in culturally embedded, ecologically adaptive food systems. The aim was to document the diversity, dietary uses, and nutritional contributions of indigenous vegetables while examining how food knowledge is transmitted across generations amid socioecological change. To achieve this, we worked closely with local counterparts, village leaders, and community members who acted as cultural brokers, translators, and facilitators of trust (Davis & Brown, 2024).

In addition to purposive selection of key informants, snowball sampling was used to identify additional participants with relevant knowledge of

Figure 1. Geographic Location of West Kalimantan in Indonesia

Source: Natural Earth (2025). Map created and modified by the authors using QGIS.

Figure 2. The Study Area in Entikong Subdistrict, Sanggau District, West Kalimantan, Indonesia

Source: Base map from OpenStreetMap contributors (2025). Visualization and highlighting of study villages by the authors.

indigenous vegetables, foraging practices, and traditional food preparation. Snowball sampling is a nonprobability recruitment technique in which initial participants recommend other individuals within their social networks who meet the study criteria, making it particularly useful for accessing specialized knowledge holders or community members engaged in specific cultural practices (Gierczyk et al., 2023; Handcock et al, 2011). This approach enabled the research team to reach individuals who continue to practice foraging, gardening, and traditional culinary preparation within the Bidayuh community, thereby enriching the study's diversity of perspectives.

Initial access to Dayak Bidayuh settlements was established through academic collaborators and local health workers with longstanding relationships in the communities. The research also aimed to understand how indigenous plant species intersect with food insecurity, malnutrition, and biodiversity decline in border settings, as well as how cultural meanings and symbolic, seasonal, and medicinal aspects shape food preferences and uses.

An exploratory phase identified suitable villages and refined the research focus on ecological knowledge and intergenerational food practices. Access was negotiated through introductions by village heads (*kepala dusun*) and elders, who guided preliminary mapping of social structures, household networks, and subsistence activities. A participatory approach was adopted to reduce social distance, clarify research objectives, and ensure that community voices informed methodological decisions (Kurniawan et al., 2024).

Following this phase, five villages were selected using a multisite strategy to capture variation in ecological access and market exposure (Figure 3). Entikong and Semanget were classified as accessible border villages with strong exposure to Malaysian markets and processed foods. Nekan was situated at the forest fringe, blending foraging, gardening, and periodic market trips. Suruh Tembawang and Pala Pasang were remote villages accessible only via small roads or footpaths, with high dependence on forest foods and swidden agriculture. This multisite village-selection strategy, designed to capture variation in ecological access, market exposure, and settlement accessibility, provided comparative insight into how settlement geography shapes food practices, ranging from predominantly foraging-based diets to hybrid diets increasingly influenced by cross-border commodities.

Key informants were initially identified using

Figure 3. Map of Study Villages in the Entikong Border Area, Sanggau District, West Kalimantan, Indonesia

Source: Base map from OpenStreetMap contributors (2024). Village boundaries and visual annotations were created and modified by the authors.

purposive (expert) sampling, selecting individuals recognized within the community for their knowledge of indigenous vegetables, plant identification, seasonal harvesting cycles, and traditional food preparation practices. Purposive or expert sampling is commonly used in qualitative and community-based research to identify "information-rich" participants with specialized knowledge relevant to the phenomenon under study (Patton, 2018). To broaden participation and reach additional knowledgeable individuals, snowball sampling was subsequently employed, whereby initial informants recommended other community members actively engaged in foraging, gardening, or gathering indigenous vegetables. Snowball sampling enables researchers to access social networks of expertise and is particularly useful for identifying participants involved in culturally embedded practices that may not be easily identifiable through conventional sampling frames (Ahmed, 2024).

Key informants included men and women aged 30–75 years who were widely recognized within the community for their expertise in plant identification, seasonal cycles, and traditional food

preparation. As key informants are intended to provide specialized knowledge rather than represent the broader population, a second group of non-key informants was included to reflect the community's general demographic characteristics. These respondents were primarily younger adults aged 18–30 years, who were less directly engaged in traditional subsistence activities but offered insights into contemporary dietary preferences and the growing influence of market-based food systems. This inclusion is particularly relevant given Indonesia's relatively young demographic structure, with a national median age of approximately 30 (Population Pyramids, 2024). The distinction between key informants and non-key informants, therefore, enabled the study to compare traditional knowledge holders with younger community members whose food consumption patterns reflect ongoing socioeconomic and dietary transitions.

Data were collected from June to October 2025 through semi-structured interviews, household surveys, foraging walks, foraging observations, and participant observation. Similar participatory field approaches have been widely applied in community-based research to better understand everyday practices and lived experiences within local environments, particularly when investigating culturally embedded activities such as food gathering and resource use (Yeo et al., 2024). Semi-structured interviews documented plant names, edible parts, harvesting sites, seasonal availability, preparation methods, consumption frequency, and associated meanings. Ambulatory interviews during walks to gardens, forest edges, and riverbanks enabled participants to contextualize plants in situ and explain ecological indicators and harvesting practices. Nutritional analyses were conducted on selected species using laboratory assessment of macro- and micronutrients. All plant images presented in this study were documented by the authors during fieldwork and were used to support species identification and local naming practices.

Data analysis combined qualitative and quantitative techniques. Interview transcripts were manually transcribed and coded using an inductive thematic analysis approach to identify recurring patterns related to plant knowledge, cultural identity, and food security (Clarke & Braun, 2017). Initial codes were generated from the interview data and subsequently grouped into broader thematic categories reflecting knowledge transmission, food practices, and perceptions of dietary change. Household survey data on consumption frequency were converted into dietary frequency tables to summarize patterns of indigenous vegetable use among respondents. Laboratory nutrient analyses were integrated into household nutrient profiles to estimate the potential contribution of selected indigenous vegetables to dietary intake. Cross-site comparisons were then conducted to assess how ecological access, market proximity, and generational differences influenced both knowledge and consumption patterns. The household questionnaire and interview guide are provided in Appendix A. A structured household questionnaire was used to document food sources, indigenous vegetable consumption, foraging practices, processed food consumption, and cross-border food market interactions. A sample of the questionnaire is presented in Appendix B. The reporting of qualitative methods and findings follows the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines, with the checklist provided in Appendix C.

Our positionality as non-Bidayuh researchers shaped both field interactions and interpretation. Following Indigenous research methodologies that emphasize relational accountability and reflexivity (Gantley, 2018), we approached fieldwork as facilitators rather than as information extractors. Throughout the research, we prioritized community consent, privacy, and collaborative interpretation, aligning with broader principles of Indigenous self-determination in research. Ethical approval for this study was granted by the Ethics Committee on Social Studies and Humanities, National Research and Innovation Agency (BRIN), Indonesia (No. 027/KE.01/SK/01/2025). Informed consent was obtained from all participants prior to data collection.

Use of AI-Assisted Analytical Tools

In addition to manual coding and thematic synthesis, AI-assisted tools were employed to support data organization and writing. ChatGPT (OpenAI) was used as an auxiliary analytical tool

to assist in text summarization, reorganize preliminary codes into thematic clusters, and improve clarity during drafting. AI output was treated as supportive rather than authoritative, with interpretive decisions grounded in field data and community input.

Results

A total of 30 respondents from five Dayak Bidayuh villages, Entikong, Semanget, Nekan, Pala Pasang, and Suruh Tembawang, participated in this study, representing a diverse cross-section of age groups, gender roles, and socioeconomic activities (Table 1). Respondents ranged in age from 34 to 73 and included farmers, hunters, traders, teachers, health workers, midwives, and craftswomen. This variation reflects the multiscalar nature of food heritage in Bidayuh communities, where knowledge is produced and transmitted through various practices, including farming, foraging, household cooking, ritual practices, handicrafts, and market exchange.

Older male respondents commonly held roles associated with ritual food practices, ecological memory, and oral history, whereas female respondents were often engaged in household cooking, food preservation, nutrition, and the transmission

Table 1. Characteristics of Informants by Village

No.	Village	Gender	Age	Occupation	Role in Food Heritage
1	Entikong	Male	67	Farmer	Ritual food practices
2	Entikong	Female	57	Homemaker	Traditional cooking
3	Entikong	Male	45	Community youth leader	Transmission of food culture
4	Entikong	Female	34	Teacher	School-based food knowledge
5	Entikong	Male	60	Trader	Local market food exchange
6	Entikong	Female	50	Weaver	Food-linked handicrafts
7	Semanget	Male	73	Retired farmer	Oral historian
8	Semanget	Female	52	Homemaker	Culinary knowledge
9	Semanget	Male	41	Hunter	Wild food gathering
10	Semanget	Female	39	Farmer's wife	Household cooking
11	Semanget	Male	64	Village elder	Ceremonial food practices
12	Semanget	Female	48	Midwife	Nutrition and healing foods
13	Nekan	Male	62	Farmer and hunter	Food gathering
14	Nekan	Female	47	Community health worker	Nutrition practices
15	Nekan	Male	35	Youth farmer	Adoption of modern crops
16	Nekan	Female	55	Homemaker	Preservation of daily meals
17	Nekan	Male	70	Retired trader	Oral memory of markets
18	Nekan	Female	42	Craftswoman	Linking crafts with foods
19	Pala Pasang	Male	57	Farmer	Rice cultivation
20	Pala Pasang	Female	62	Homemaker	Preservation methods
21	Pala Pasang	Male	38	Hunter	Protein source (game meat)
22	Pala Pasang	Female	36	Teacher	Passing on food knowledge
23	Pala Pasang	Male	66	Village elder	Ritual food custodian
24	Pala Pasang	Female	49	Farmer's wife	Household cooking knowledge
25	Suruh Tembawang	Male	52	Small-scale livestock rearer	Protein sources
26	Suruh Tembawang	Female	67	Homemaker and artisan	Fermentation methods
27	Suruh Tembawang	Male	44	Farmer	Mixed farming food sources
28	Suruh Tembawang	Female	59	Weaver	Food-related crafts
29	Suruh Tembawang	Male	61	Community elder	Custodian of traditional diet
30	Suruh Tembawang	Female	40	Young mother	Everyday child nutrition

of artisanal knowledge. Participants from the younger age group within the sample (mid-30s to mid-40s), including both men and women, contributed perspectives on shifting practices, the adoption of modern crop varieties, and evolving dietary preferences influenced by market integration. Collectively, this respondent profile enabled the study to capture both specialist knowledge and everyday food practices across generations and settlement types.

From the interview transcripts, participant observation, and multi-site comparisons, five interrelated themes emerged: (1) hybrid livelihood and cash-based dependency, (2) dietary transitions and the role of border markets, (3) cultural significance of indigenous dishes, (4) erosion of ecological knowledge and intergenerational gaps, and (5) gendered constraints in food provisioning (Figure 4). These themes illuminate how Dayak Bidayuh households negotiate cultural food heritage within an increasingly modernized borderland economy.

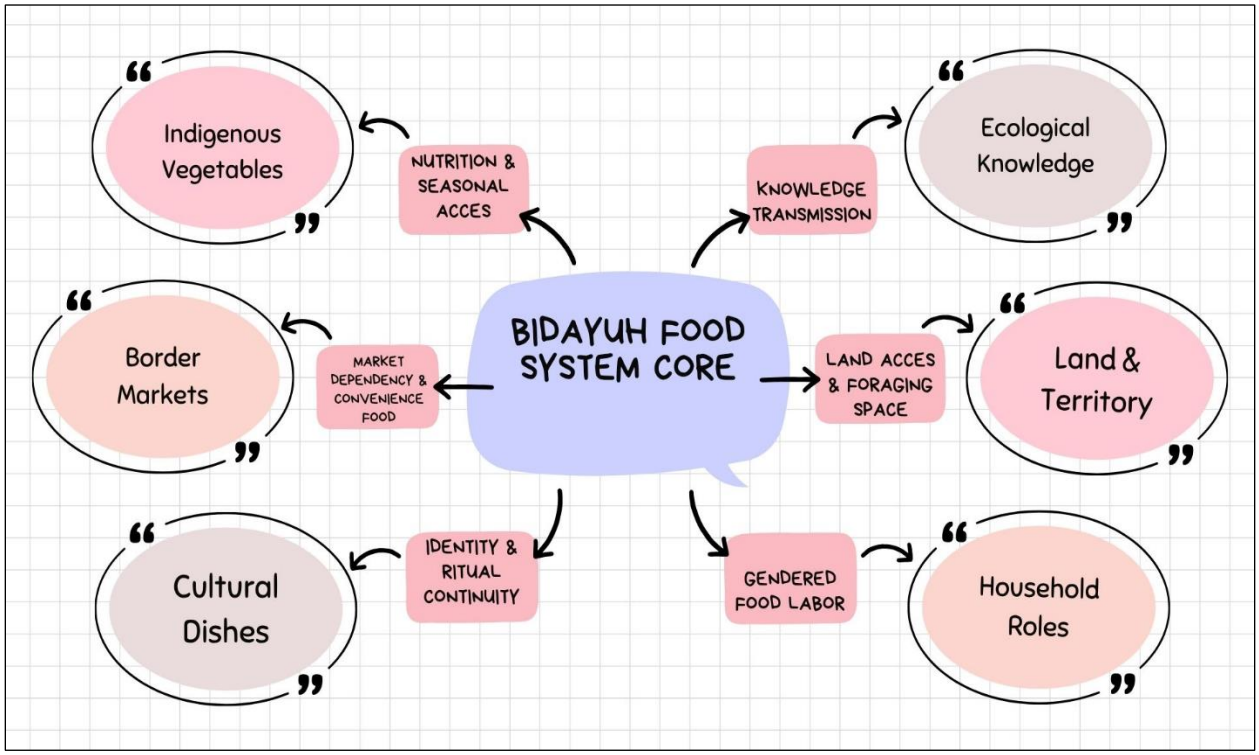
Hybrid Livelihood and Cash-Based Dependency

Despite changing practices, subsistence agriculture and foraging remain elements of the local food system; most households now integrate wage labor, cross-border trading, and seasonal commodity sales into their livelihoods. Data from interviews suggest that increasing dependence on Malaysian markets has reshaped local food economies, with rice, instant noodles, processed snacks, and bottled beverages becoming everyday staples.

Several older participants noted that younger generations prioritize wage earnings over foraging, reducing wild foods within household diets. As one community elder explained at length:

> In the past, we did not talk much about buying food because everything we needed was nearby, rice from the *ladang*, vegetables from the forest, meat from hunting, or chickens we raised. But now it is different. Many of our young people work as drivers, porters, or trad-

Figure 4. Conceptual model of the Bidayuh Food System Core



Source: Developed by the authors based on thematic analysis of qualitative data using NVivo.

> ers, or cross the border to Malaysia to find daily wages. When they come home in the evening, there is no time to go to the forest. So the wife buys cabbage, carrots, or instant noodles from the shop. It is faster. But it also means our food depends on money and prices, not just on seasons or our knowledge. When the border was closed during COVID, we really felt how much we have changed because people found it difficult to buy food. Some of us went back to the forest for bamboo shoots and leaves. As you can see, we now depend on both worlds. (Informant 17, Male, 70 years old, Nekan)

This statement illustrates how hybrid economies create both flexibility and vulnerability, particularly during border disruptions, seasonal shortages, and price fluctuations.

Dietary Transitions and the Role of Border Markets

The increased availability of commercial vegetables and processed foods, especially from markets in Tebedu and Serian (Sarawak), has altered cooking practices. In more accessible villages, indigenous vegetables account for an estimated 10–15% of weekly household vegetable intake, compared to 30–40% in forest-fringe settlements. Purchased foods now fill dietary gaps that were historically supplied by wild greens and tubers.

One middle-aged female respondent described the impact of border markets on everyday meals in detail:

> Before the big shops came, our cooking was mostly what we found or planted such as *pucuk paku* (edible fern shoots), *daun ubi* (cassava leaves), bamboo shoots, and whatever fruits or mushrooms we could collect. Even chicken was only for special days. However, it is now normal to buy chicken from the freezer and sometimes vegetables from the market in Malaysia. If my daughter calls me from Serian and asks what I want, I say cabbage or carrots because they are cheap there. For wild vegetables, I still cook them when I have time or when older relatives visit, because they miss the taste. However, young people in Tebedu or Entikong prefer fast food. They say it is easier and more modern. So, our kitchen reflects the border. We mix our heritage with whatever we can buy on the other side. (Informant 8, Female, 52 years old, Semanget)

This shift suggests not only dietary diversification but also a reconfiguration of cultural value, convenience, and identity.

Cultural Significance of Bidayuh Dishes

Despite rapid dietary modernization, several indigenous dishes continue to play a central role in Dayak Bidayuh identity, ritual life, and collective social gatherings. These dishes are deeply embedded in cultural memory and rely on indigenous vegetables, forest herbs, and traditional preparation techniques that reinforce connections to land and community. *Sayur rampai* represents a good example of this continuity. It is prepared from a mixture of wild or garden leaves, such as *pucuk ubi* (cassava shoots), *daun kucai (*garlic chives), *daun bawang bukit* (wild mountain onion/ wild chives), and bamboo shoots, often cooked together with coconut milk and occasionally dried fish. The dish embodies both culinary diversity and the ecological knowledge required to identify and collect seasonal leafy vegetables. The preparation of mixed wild greens also reflects a broader culinary tradition found in many cultures, where foraged leafy plants are cooked together as part of everyday diets and seasonal food practices. Comparable traditions include the preparation of wild greens dishes in the southern United States, South Asian *saag*, and mixed Asian leafy vegetable dishes, all of which highlight the cultural importance of gathering and cooking diverse local greens as expressions of regional food heritage (Cook Me Indonesian, 2022; The Intrepid Eater, 2023; Wild Greens and Sardines, 2020).

Pekasam is a traditional fermented fish product widely found in Indonesia and Malaysia, produced through spontaneous fermentation involving lactic acid bacteria that contribute to its distinctive sour flavor and preservation properties (Mahyudin et al., 2015). Meanwhile, *ayam pansuh*, chicken cooked in bamboo with forest herbs such as *bawang hutan*

(wild shallots), *serai* (lemongrass), and *daun bungkang*, a local forest herb, remains closely associated with harvest rituals and communal celebrations. Beyond flavor, the dish encodes values of respect for the forest, cooperation, and ceremonial reciprocity. Together, these dishes illustrate how Bidayuh foodways are not only nutritional systems but cultural technologies that sustain identity, intergenerational knowledge, and social cohesion in the borderland context. During fieldwork in Suruh Tembawang, women emphasized that these dishes are markers of identity:

> *Ayam pansuh* (bamboo-cooked chicken) is not just food; it is how we celebrate family, guests, and big days. When people come from Pontianak or Kuching, we cook pansuh as a sign of respect. The herbs come from the forest, and only certain people know which leaves to use. If you use the wrong leaves, the taste will be weak or bitter. *Sayur rampai* is everyday food. We mix whatever leaves we have. *Pek-asam* is food for difficult times because it lasts a long time. These foods teach our children who they are, even if they go far away later. (Informant 28, Female, 59 years old, Suruh Tembawang).

Such culinary practices sustain continuity between ecological knowledge, social ties, and identity within the Bidayuh community. At the same time, Indonesian cuisine more broadly has gained international recognition through widely published cookbooks that introduce regional dishes and culinary traditions to global audiences, including works such as *Indonesian Cooking: Satays, Sambals and More* by Dina Yuen, *Mortar and Pestle: Classic Indonesian Recipes for the Modern Kitchen* by Patricia Tanumihardja, and *Coconut & Sambal: Recipes from My Indonesian Kitchen* by Lara Lee.

Erosion of Ecological Knowledge and Intergenerational Gaps

Interviews revealed substantial generational differences in knowledge of edible species, harvesting grounds, and ecological signals (e.g., the emergence of bamboo shoots after rain). Elders could identify 20–30 edible plant species with detailed harvesting instructions; however, many younger respondents could identify fewer than five, usually limited to *pucuk ubi* (cassava shoots), *daun singkong* (cassava leaves), and *pucuk paku* (fern shoots).

A retired farmer described his concerns at length:

> When I was younger, my father took me to the forest almost every week. He taught me how to recognize plants, how to smell the leaves, and how to determine if the shoots were edible. Now, children do not follow us to the forest. They follow the school schedule, the handphone, and the internet. If we ask them to join, they say it is tiring or there are mosquitoes. I am worried because knowledge is not written in books; it is in our memory. If no one learns it, it will disappear. Then one day our grandchildren will see a wild vegetable and not know if it is food or poison. (Informant 7, Male, 73 years old, Semanget)

This statement illustrates how ecological knowledge related to edible plants, such as cassava shoots, cassava leaves, and fern shoots is traditionally transmitted through direct participation in forest-based activities. As younger generations spend less time in farming and foraging environments, opportunities for experiential learning decline, contributing to the gradual erosion of traditional ecological knowledge within the community.

Role of Indigenous Vegetables in Household Food Security

Across all five villages, indigenous vegetables remain central to daily household food provisioning, functioning as both primary ingredients for routine meals and fallback foods during periods of cash shortages or market inaccessibility. Participants frequently emphasized the abundance and accessibility of leafy greens, edible shoots, gingers, ferns, and wild herbs found in swidden fields, home gardens, and forest edges. Species such as *pucuk ubi* (cassava shoots), *daun kucai* (garlic chives), *daun bawang bukit* (wild mountain onion/wild chives), *rebung* (bamboo shoots), *kelakai* (edible fern/*Stenochlaena palustris*), *bawang hutan* (wild shallots/*Eleutherine bulbosa*), and wild gingers were con-

sistently mentioned as seasonal staples that help reduce dependence on purchased foods (Figures 5–10).

For many households, indigenous vegetables serve as a crucial buffer against nutritional and economic shortages. Several participants described how market-bought vegetables are often reserved for ceremonial events or when household finances allow, whereas indigenous vegetables are relied upon during "difficult weeks," especially when

Figure 5. *Pucuk Ubi* (Cassava Shoots)

Figure 6. *Daun Kucai* (Garlic Chives)

Figure 7. *Daun Bawang Bukit* (Wild Mountain Onion/Wild Chives)

Figure 8. *Rebung* (Bamboo Shoots)

Figure 9. *Kelakai* (Edible Fern/*Stenochlaena palustris*)

Figure 10. *Bawang Hutan* (Wild Shallots/ *Eleutherine bulbosa*)

Source: Photographs of indigenous vegetables documented during fieldwork by the authors, Entikong Sub-district, West Kalimantan, Indonesia, 2025

income is irregular or cross-border travel is restricted. One farmer explained that :

> When cash runs out, we don't panic because the vegetables around the village are always there. Tapioca shoots, ferns, wild garlic leaves, bamboo shoots, those foods never disappear. We sometimes buy vegetables from across the border, but when the weather is bad, or the checkpoint closes early, we return to what we call *sayur kampung* [traditional local vegetables]. My wife says these vegetables don't require money, only labor and knowledge. We grew up with them, so we know when bamboo shoots appear, when certain leaves turn bitter, and when their smell tells you they're good for cooking. That's why when the price of cooking oil increases or the market becomes too expensive, our meals continue. Border communities survive because we still have plants that don't come from shops. (Informant 19, Male, 57 years old, Pala Pasang)

Gendered Constraints and Time Burden

Food-related labor remains gendered, with women managing cooking, fermentation, and childcare, while men have historically hunted and gathered forest vegetables. However, modern wage labor and trade have reduced men's participation in forest activities, increasing women's time burdens or forcing households to substitute wild foods for purchased produce. Women in Suruh Tembawang and Pala Pasang reported foraging trips of 3–6 hours, compared to 1–2 hours in the past. A community health worker explained:

> To get *daun empasak* or bamboo shoots now, we must walk far, sometimes across old logging roads or up the hills. If I go alone, it takes half a day, and when I return, I still must cook, clean, and take care of the children. So sometimes I choose to buy vegetables from the market because it is easier. My mother-in-law says it tastes different, and she is right, but time is also important now. Women carry many responsibilities, and the forest does not wait for us as it did before. (Informant 14, Female, 47 years old, Nekan)

These shifts highlight how food transitions intersect with gender, labor, and ecological change.

Applied Relevance for Food System Development

The findings illustrate several entry points for strengthening local food systems. First, indigenous vegetables remain nutritionally relevant and seasonally available, offering a low-cost food source during periods when market foods are unaffordable or inaccessible. Second, cross-border markets create both opportunities and vulnerabilities: Households gain exposure to diverse food items and additional income streams, yet dependence on convenience foods may increase as fresh vegetables are replaced with processed imports. Cross-border mobility in Entikong is facilitated through special border travel permits such as the *Pas Lintas Batas* (PLB) and *Kartu Identitas Lintas Batas* (KILB), which allow residents of designated border areas to cross into Sarawak for small-scale trade and daily activities. This mobility can influence household food purchasing patterns and market access within the borderland food system. Third, intergenerational gaps in food knowledge indicate a fragile mechanism of knowledge transmission, suggesting that food system interventions must integrate cultural transmission alongside agricultural support. Fourth, land access continues to shape foraging practices and seasonal diets, making territorial access a food security issue rather than a purely cultural one.

Together, these insights offer actionable leverage points for community-based food system development rather than merely providing ethnographic description. The study area is also situated within the broader Brunei–Indonesia–Malaysia–Philippines East ASEAN Growth Area (BIMP-EAGA), a subregional cooperation initiative intended to stimulate economic development in peripheral regions through improved connectivity and cross-border trade. However, as noted in recent analyses, the benefits of these regional initiatives remain uneven across districts and rural communities.

Discussion

The BIMP-EAGA region is characterized by considerable ethnic diversity. Our findings suggest that

structural factors such as land access, generational knowledge transmission, and exposure to market food systems play a more decisive role than ethnicity alone in shaping the persistence or transformation of indigenous food practices in the Entikong borderland.

Building on the findings from semi-structured interviews, participatory observation, ecological mapping, and culinary ethnography, this study collaborated with Bidayuh key informants and household-level participants to co-develop a conceptual model of food heritage and food system resilience in the Indonesia–Malaysia borderlands. Rather than treating Indigenous food practices as static traditions, the model frames Bidayuh food knowledge as a dynamic system shaped by land access, ecological literacy, household labor, and cross-border market forces. Centering community voices helped ensure that the framework responds to local priorities, such as cultural food identity, access to forest vegetables, and dietary adaptation; nevertheless, it also acknowledges external pressures on Bidayuh diets, livelihoods, and cultural continuity (Ting et al., 2017; Utomo, 2021).

Food Heritage and Food System Dynamics

Bidayuh communities in Entikong have undergone rapid transformation due to infrastructure expansion, commercialization, and changes in land use. These shifts affect dietary composition, ecological knowledge transfer, and gendered labor in agriculture and foraging, patterns consistent with Indigenous food system transitions elsewhere in Southeast Asia (Ajibola et al., 2023; Casas et al., 2024; Tan et al., 2024). Reduced access to forest edges limits wild vegetable foraging, while the proliferation of border markets increases exposure to packaged foods, echoing findings among upland minorities facing state territorialization and pressures from commercial agriculture (Caviedes et al., 2024; Ege et al., 2022).

For the Bidayuh, food is inseparable from ancestral land (*tanah adat*), seasonal calendars, and ritual identity (Hartini, 2019; Widiyarto et al., 2020). The conceptual model developed here highlights six interconnected components: indigenous vegetables, ecological knowledge, land and territory, household roles, cultural dishes, and border markets, linked through mechanisms such as knowledge transmission, gendered labor, ritual continuity, and market dependency (Figure 10).

Territory, Self-Determination, and Identity

The findings align with broader arguments that food sovereignty is inseparable from territorial self-determination (Puspitasari et al., 2024; Seran & Mardawani, 2020). Land constitutes a cultural and epistemic space where food knowledge and identity are enacted (Simanjuntak & Erwinsyah, 2020). In border settings, territorial issues intensify due to overlapping jurisdictions, commodity flows, and limited recognition of customary land (Sulaiman et al., 2024). In addition, deforestation and land-use change in parts of Borneo have reduced access to forest resources that historically supported foraging and the collection of wild edible plants. Elders' statements that "without land, there is no forest, and without forest, there is no food" mirror Indigenous food movements globally (Suswandari et al., 2022; Tamang, 2010). Even without the strong legal advocacy platforms seen in other Indigenous contexts, cultural self-determination through food, the maintenance of ritual dishes, seed exchanges, and customary slaughter functions as an everyday form of sovereignty within fragmented governance structures (Casas et al., 2024; Firdaus et al., 2019).

Border Markets and Economic Adaptation

The Entikong–Tebedu border corridor illustrates a classic cross-border food economy. Households frequently reported relying on Malaysian processed foods due to their affordability and convenience. The reports reflect regional trends in which imported, energy-dense processed foods, such as instant noodles, packaged snack foods, sweetened beverages, and processed meat products, displace traditional diets (Li J., 2022; Miranda, 2022; Ting, H., 2017). This creates market dependence and lowers incentives to forage, especially among youth.

However, border markets are not purely extractive. Bidayuh farmers also sell bamboo shoots, vegetables, and fruits across the border, forming micro-value chains similar to Indigenous trade systems in Sarawak, Sabah, and Kalimantan

(Chua, 2009; Ege et al., 2022; H. Li et al., 2024). Thus, border economies simultaneously erode and enable Indigenous food systems, depending on how value chains are structured.

Cultural Food Heritage and Knowledge Transmission

Bidayuh dishes such as ayam pansuh, sayur rampai, and pekasam encode ecological adaptation, seasonal availability, and ritual significance. Similar to other Indigenous contexts, communal meals reinforce social cohesion and moral economies (Harmayani et al., 2019; Ray, 2015). Interviews reveal that older women are the primary custodians of culinary knowledge, aligning with the existing literature on the gendered nature of food knowledge transmission (Chinea et al., 2020; Minton et al., 2019). Youth disinterest and urban migration threaten this process, mirroring Indigenous cases in Taiwan, Canada, and Malaysia, where schooling and digital media are eroding ecological literacy (Abdul, 2017; Hong, 2025; Jiménez- Moreno et al., 2023). Revitalization strategies such as festivals, food education, and intergenerational cooking may bolster cultural resilience.

Nutrition Transitions and Health

Dietary transitions among Bidayuh households reflect a broader nutritional transition toward refined carbohydrates, sugars, and oils, thereby heightening the risks of noncommunicable diseases (Hu, 2011; J. Li et al., 2022). Elders reported favoring foraged vegetables and home-cooked foods; however, youth preferred instant noodles and sugary drinks, patterns consistent with Hunter et al.'s (2021) nutrition transition model. Meanwhile, forest vegetables like ferns, bamboo shoots, and leafy greens contain micronutrients and antioxidants (Hunter et al., 2021; Utomo, 2021). Preserving indigenous vegetables therefore, represents both a cultural and public health strategy aligned with Indigenous food sovereignty arguments for metabolic and cultural well-being (Hu, 2011; J. Li et al., 2022).

Biodiversity, Ecological Knowledge, and Sustainable Development

Bidayuh ecological knowledge constitutes a form of traditional ecological knowledge (TEK) that directly shapes how biodiversity is accessed, managed, and sustained within local food systems. This knowledge system encompasses plant identification, seasonal harvesting cycles, and culturally embedded norms of resource use, such as selective harvesting, rotation of foraging sites, and minimal extraction of key species (Astutik et al., 2018; Azmi et al., 2017; Rusliyadi et al., 2019). In practical terms, TEK functions as an informal management system that regulates human–environment interactions and supports the long-term availability of indigenous vegetables (Sageng et al., 2024; Sanggin et al., 2016). However, as this study indicates, reduced access to forest areas and declining participation of younger generations in subsistence activities are weakening the transmission of this knowledge, creating risks not only for cultural continuity but also for biodiversity-dependent food systems (Hunter et al., 2021; Utomo & Widjaja, 2021).

These findings clarify the relevance of TEK within broader sustainability frameworks, particularly its contribution to multiple Sustainable Development Goals (SDGs). The use of indigenous vegetables supports SDG 2 (Zero Hunger) by enhancing dietary diversity and local food availability, while sustainable harvesting practices align with the principles of SDG 12 (Responsible Consumption and Production). At the same time, the reliance on forest biodiversity and the maintenance of ecological knowledge systems are closely linked to SDG 15 (Life on Land). They are also indirectly linked to SDG 13 (Climate Action) through the preservation of resilient, low-input food systems (FAO et al., 2021; Nepal, 2025). By explicitly linking TEK to these outcomes, this study demonstrates that Indigenous food practices are not only culturally significant but also function as locally grounded strategies for biodiversity conservation and sustainable development in borderland contexts.

Ethical Space and Collaborative Knowledge Production

Indigenous research methodologies emphasize an ethical space in which Indigenous and academic worldviews coexist without hierarchy (Hartini &

Fusnika, 2019; Hoang et al., 2026). This study adopted an approach that allowed participants to define food priorities and ecological relationships using Bidayuh categories, rather than Western abstractions. Ethical collaboration prevents knowledge from being fragmented into "scientific pieces" detached from cultural and cosmological systems (Kuhnlein et al., 2013; Macours, 2019; Widiyarto et al., 2020). For food system work, ethical space enhances community legitimacy and cultural fidelity.

Scalability and Practitioner Implications

Nevertheless, the Bidayuh model is context-specific; it is conceptually transferable if adapted to border dynamics, customary land tenure, gendered labor, and culinary identity. Similar polycentric approaches are also evident in other Indigenous food sovereignty initiatives (Rozaki, 2020; Widiyarto, 2022; Yuslie et al., 2021). Strengthening Bidayuh food systems is therefore not only a cultural exercise but also a strategy for dietary diversification, biodiversity conservation, and economic resilience in border settings.

Limitations

Certain procedures recommended in the COREQ checklist were not implemented in this study. Repeat interviews were not conducted because the research design relied on single-session interviews combined with participant observation and field notes to capture participants' perspectives. Returning transcripts to participants for correction was also not feasible due to logistical constraints and the dispersed nature of households in the border villages. Similarly, formal member checking was not conducted; however, findings were triangulated through multiple data sources, including interviews, participant observation, and cross-site comparisons across villages. These approaches were used to enhance the credibility and consistency of the qualitative analysis, respecting the practical constraints of fieldwork in remote border communities.

Recommendations and Future Research

The findings suggest several practical directions for strengthening Indigenous food systems in border regions such as Entikong. One potential pathway involves the development of managed foraging programs, where communities, local governments, and universities collaborate to document edible plant species, establish sustainable harvesting guidelines, and integrate ecological monitoring. Such initiatives could help preserve TEK and ensure that forest resources are used responsibly.

A second opportunity lies in strengthening micro–value chains for Indigenous vegetables and forest foods, enabling local producers to market traditional products, such as bamboo shoots and seasonal greens, through community markets or cross-border trade networks. At the same time, youth-oriented knowledge transmission programs, including school-based ecological education and community food festivals, could help bridge generational gaps in ecological knowledge. Future research could examine how these initiatives can be implemented through partnerships among universities, local governments, and Indigenous communities, particularly in borderland contexts where food systems are shaped by both ecological and cross-border economic dynamics.

Conclusion

Our findings demonstrate that in Entikong, food sovereignty continues to be anchored in households' daily consumption of indigenous vegetables within Dayak Bidayuh communities and emphasize their importance as a safety net for household food systems during economic shocks, limited market access, or both. These locally available plant resources continue to play an important role in maintaining dietary diversity and building a resilient hybrid food system through subsistence-oriented practices alongside the cash economy, despite increasing reliance on cross-border markets and on processed foods. But these systems are beleaguered. The loss of traditional ecological knowledge that sustains Indigenous food systems is being catalyzed by factors such as rapid dietary shifts, diminishing participation of younger generations in foraging and agriculture, and blanket restrictions on forest products.

The results clearly show that we cannot think of Indigenous food systems simply as frozen cultural artifacts, but instead have to see them as

dynamic systems continuously changing through land access, labor patterns, gender roles, and market integration. To strengthen these systems, there is an urgent need for tailored and contextualized interventions that include securing access to customary land, intergenerational transfer of knowledge, and establishment of local value chains for indigenous vegetables. It has been argued that this gradual loss of ecological knowledge will, in turn, led to a greater dependence on the external food system and eventually threaten both long-term food security and cultural continuity without such interventions. Within this context, maintaining indigenous vegetables is not only a question of nutrition but rather a strategy to strengthen resilience and food sovereignty in borderland populations.

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Appendix A. Semi-Structured Interview Guide for Household and Key Informants

Section 1. Respondent Background

1. What is your age?
2. What is your gender?
3. What is your main occupation?
4. How long have you lived in this village?
5. What are your main sources of livelihood (e.g., farming, trading, wage labor, forest products)?

Section 2. Indigenous Vegetables and Foraging Practices

6. What types of indigenous vegetables or forest plants are commonly consumed in your household?
7. Where are these plants usually obtained (forest, farm, garden, market)?
8. Who in the household usually collects or prepares these vegetables?
9. Are there particular seasons when these plants are more abundant?
10. How do you identify which plants are safe to eat?

Section 3. Traditional Ecological Knowledge (TEK)

11. How did you learn about edible plants or vegetables in the forest or fields?
12. Who taught you these skills?
13. Are younger generations still learning how to identify and collect these plants?
14. Have you noticed changes in how people use or collect these plants over time?
15. Are there traditional rules or customs related to harvesting plants from the forest?

Section 4. Food Consumption and Dietary Changes

16. What foods are most commonly eaten in your household today?
17. Compared to the past, have eating habits changed in your community?
18. What kinds of processed or packaged foods are commonly consumed today?
19. Do younger people prefer different foods compared to older generations?
20. In your opinion, are traditional foods still important for health and culture?

Section 5. Cross-Border Markets and Food Access

21. Do households in this village buy food from markets across the border?
22. What kinds of foods are usually purchased from Malaysian markets?
23. Are these foods cheaper, more convenient, or preferred for other reasons?
24. Do households also sell vegetables, fruits, or forest products across the border?
25. How does cross-border trade affect local food availability?

Section 6. Land Access and Environmental Change

26. Where do households usually collect forest foods?
27. Has access to land or forest areas changed in recent years?
28. Have you noticed any changes in forest resources or plant availability?
29. What factors affect your ability to collect traditional foods today?
30. In your opinion, how important is land and forest access for maintaining traditional diets?

Section 7. Cultural Significance of Indigenous Foods

31. Are there traditional dishes that use indigenous vegetables?
32. When are these dishes usually prepared (daily meals, rituals, celebrations)?
33. Which dishes are considered culturally important in the community?
34. Do younger people still know how to cook these traditional foods?

Section 8. Future Perspectives

35. What challenges threaten the continuation of traditional food practices?
36. What could be done to preserve knowledge about indigenous vegetables?
37. Would programs such as community gardens, foraging training, or food festivals help maintain these traditions?
38. What role should government or universities play in supporting traditional food systems?

Appendix B. Household Survey Questionnaire

Section A. Household Characteristics

1. Age of respondent: _____
2. Gender:
   ☐ Male
   ☐ Female
3. Main occupation:
   ☐ Farmer
   ☐ Trader
   ☐ Wage labor
   ☐ Government employee
   ☐ Other: _____
4. Household size: _____ persons
5. How long has your household lived in this village?
   ☐ Less than 5 years
   ☐ 5–10 years
   ☐ More than 10 years
   ☐ Since birth

Section B. Food Sources

6. Where does your household usually obtain vegetables?
   ☐ Home garden
   ☐ Forest/foraging
   ☐ Local market
   ☐ Cross-border market (Malaysia)
   ☐ Purchased from traders
7. Which food sources are most important for your household? (Select up to three)
   ☐ Own farm production
   ☐ Forest foods
   ☐ Local markets
   ☐ Cross-border markets
   ☐ Packaged foods

Section C. Indigenous Vegetable Consumption

8. Which indigenous vegetables does your household consume? (Multiple answers possible)
9. ☐ Cassava leaves (*Manihot esculenta*)
   ☐ Fern shoots (*Diplazium esculentum*)
   ☐ Pumpkin leaves (*Cucurbita* spp.)
   ☐ Bamboo shoots (*Bambusa* spp.)
   ☐ Kelakai fern (*Stenochlaena palustris*)
   ☐ Other: _____

10. How often does your household consume indigenous vegetables?

Frequency	Response
Daily	☐
Several times per week	☐
Once per week	☐
Rarely	☐
Never	☐

Section D. Foraging Practices

11. Does your household collect edible plants from forests or fields?
    ☐ Yes
    ☐ No

    If yes:

    Who usually collects these plants?
    ☐ Adult men
    ☐ Adult women
    ☐ Elderly household members
    ☐ Children/youth
    ☐ Entire household

12. How often does your household collect forest foods?

Frequency	Response
Weekly	☐
Monthly	☐
Occasionally	☐
Rarely	☐

Section E. Processed Food Consumption

13. Which processed foods are commonly consumed in your household? (Multiple answers possible)
    ☐ Instant noodles
    ☐ Packaged snack foods
    ☐ Sweetened beverages
    ☐ Processed meat products
    ☐ Other: _____
14. How often are these foods consumed?

Frequency	Response
Daily	☐
Several times per week	☐
Occasionally	☐
Rarely	☐

Section F. Cross-Border Food Markets

15. Does your household purchase food from Malaysian markets?
    ☐ Yes
    ☐ No

If yes:

16. What foods are typically purchased across the border?
    ☐ Packaged foods
    ☐ Fresh vegetables
    ☐ Fruits
    ☐ Meat or fish
    ☐ Other: _____
17. Why does your household buy food across the border?
    ☐ Lower price
    ☐ Better availability
    ☐ Better quality
    ☐ Convenience
    ☐ Other: _____

Section G. Perceptions of Traditional Food Systems

18. Do you think traditional vegetables are important for household nutrition?
    ☐ Very important
    ☐ Important
    ☐ Not very important
    ☐ Not important
19. Are younger people still interested in traditional vegetables?
    ☐ Yes
    ☐ Somewhat
    ☐ No
20. What do you think is the biggest challenge for maintaining traditional food practices?
    ☐ Loss of land access
    ☐ Declining forest resources
    ☐ Changing food preferences
    ☐ Market dependence
    ☐ Other: _____

Appendix C

COREQ Checklist (Consolidated Criteria for Reporting Qualitative Research)

No.	Item	Description	Addressed in Manuscript
Domain 1: Research Team and Reflexivity			
1	Interviewer/facilitator	Interviews were conducted by the lead researcher with support from local research assistants familiar with the Bidayuh language and culture	Methods
2	Credentials	The lead researcher holds a background in public health and community-based research on food systems	Methods
3	Occupation	The researcher was affiliated with a university research team during the study	Methods
4	Gender	Interviews were conducted by a male researcher with support from male and female local assistants	Methods
5	Experience and training	The research team had prior experience in community-based qualitative research and ethnographic fieldwork	Methods
6	Relationship established	Initial contact with participants was facilitated through village leaders and community representatives	Methods
7	Participant knowledge of the interviewer	Participants were informed about the research objectives and the role of the researcher	Methods
8	Interviewer characteristics	The research team acknowledged the importance of cultural sensitivity when discussing Indigenous food practices	Methods
Domain 2: Study Design			
9	Methodological orientation	The study employed a qualitative approach combining semi-structured interviews, participant observation, and thematic analysis	Methods
10	Sampling	Purposive sampling was used to identify knowledgeable informants, followed by snowball sampling to recruit additional participants	Methods
11	Method of approach	Participants were approached through community leaders and personal referrals	Methods
12	Sample size	A total of 30 respondents participated in the interviews	Methods
13	Non-participation	No participants withdrew from the study after consent was obtained	Methods
14	Setting of data collection	Interviews were conducted in villages in the Entikong border region of West Kalimantan	Methods
15	Presence of non-participants	In some cases, family members were present during interviews in household settings	Methods
16	Description of sample	Participants included farmers, traders, teachers, health workers, and community elders	Results
17	Interview guide	Semi-structured interview questions explored indigenous vegetable use, food practices, and cross-border food trade	Appendix A
18	Repeat interviews	Repeat interviews were not conducted	Methods
19	Audio/visual recording	Interviews were recorded and supplemented with field notes	Methods
20	Field notes	Observational notes were taken during and after interviews	Methods
21	Duration	Interviews lasted approximately 30–60 minutes	Methods
22	Data saturation	Data collection continued until thematic saturation was reached	Methods
23	Transcripts returned	Transcripts were not returned to participants for correction	Methods

continued

Table C, continued

No.	Item	Description	Addressed in Manuscript
Domain 3: Analysis and Findings			
24	Number of data coders	Coding and thematic analysis were conducted by the lead researcher	Methods
25	Description of coding tree	Codes were developed inductively to identify themes related to food practices, ecological knowledge, and market dynamics	Methods
26	Derivation of themes	Themes emerged through inductive thematic analysis of interview transcripts and field observations	Methods
27	Software	Coding and analysis were conducted manually	Methods
28	Participant checking	Member checking was not conducted	Methods
29	Quotations presented	Participant quotations are presented in the results section to illustrate key themes	Results
30	Data and findings consistent	Findings presented in the results are consistent with the interview data	Results
31	Clarity of major themes	Major themes include cross-border food markets, dietary transitions, ecological knowledge erosion, and cultural food practices	Results
32	Clarity of minor themes	Minor themes include gender roles in food preparation and generational knowledge gaps	Results

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Student voices: A mixed-method approach to understanding the quality of life of students living with food access barriers

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Abstract

Grounded in Maslow's hierarchy of needs, this mixed-methods study examined how food access influences the quality of life (QoL) among college agriculture students. Because food is a fundamental physiological need, inadequate access can impede students' physical, psychological, and social well-being, as well as their academic success. This study aimed to identify barriers to food access and determine the factors most strongly associated with students' QoL.

A concurrent and sequential mixed-methods design was utilized. Phase 1 consisted of a cross-sectional online survey distributed to 3,336 undergraduate students, resulting in 809 responses (24% response rate). Multiple linear regression analysis revealed a statistically significant model (p = .017) explaining 27.7% of the variance in QoL. Significant predictors included food access, first-generation status, senior classification, and Asian ethnicity. Phase 2 consisted of 19 semi-structured

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See disclosures on next page.

interviews that explored the lived experiences underlying the survey findings. Thematic analysis identified nine key themes: barriers to food access, unawareness of resources, financial strain, lack of meal plan funds, limited food options, and the effects of food insecurity on physical health, psychological well-being, social relationships, and academic performance.

Students reported that demanding schedules, transportation challenges, and limited institutional support constrained their ability to access nutritious food. The results highlight food access as a central determinant of students' QoL and educational persistence. Institutions should enhance awareness of available resources, provide financial and meal plan assistance, and ensure inclusive dining options to promote student well-being and academic success.

Keywords
food access, quality of life, college food security, first-generation, college student

Introduction

Many college students face significant challenges accessing sufficient and nutritious food. Today's students are particularly vulnerable to experiencing food insecurity due to the escalating expenses of tuition, childcare, groceries, rent, and utilities (El Zein et al., 2019; Henry, 2017; Tanner et al., 2023). According to Nelson et al. (2009), only a small percentage of young adults attending two-year and four-year institutions adhere to an optimal diet for their needs. Additionally, students who face food access concerns are at a higher risk of encountering academic and health challenges during their school years. Research indicates that these challenges include lower GPAs, decreased academic performance, higher rates of non-completion, and poorer mental and physical health outcomes, among others (Hall et al., 2019; Patton-López et al., 2014; Payne-Sturges et al., 2018; Regan, 2020).

Food access barriers raise significant concerns and have long-term consequences for individuals' overall quality of life (QoL; U.S. Department of Agriculture, Economic Research Service [USDA ERS], 2026). According to the World Health Organization (WHO, 2006) and the Centers for Disease Control and Prevention (CDC; 2000), QoL encompasses various dimensions, such as physical, mental, and social well-being, and individuals' perceptions of their life circumstances within their cultural and social contexts. Access to food plays an important role in determining an individual's QoL. When individuals lack adequate access to food that provides the energy their bodies need, their ability to participate in daily activities can be compromised. This can result in adverse outcomes across physical health, psychological well-being, social relationships, and environmental factors (Donatelle & Ketcham, 2018; Umberson & Montez, 2010; WHO, 2012). Furthermore, academically, insufficient nutrition can impair cognitive function, concentration, and academic performance, ultimately hindering students' educational attainment and prospects (Taras, 2005).

Despite the well-documented impact of food access on QoL, a critical gap remains in the literature regarding how this relationship manifests among college students—particularly those studying agriculture. Agriculture students are uniquely positioned within this issue, as they are deeply engaged in food systems yet may still experience food insecurity. Understanding the specific factors influencing their food access and QoL is essential because their educational and professional trajectories directly intersect with food production, sustainability, and security.

While existing research has highlighted the negative consequences of food insecurity, there is a need for more comprehensive studies that examine the nuanced relationship between food access and QoL among agricultural students. This mixed-methods study addresses this gap by exploring key factors that affect their food security, identifying

Author Note
This project was the doctoral dissertation of Lana Petrie (2023). Dr. Rick Rudd was the committee chair and advisor of Petrie.

Statement of Ethical Conduct
This study was approved by the Virginia Tech Institutional Review Board (IRB Number 22-913).

Conflicts of Interest
The authors have no conflicts of interest to disclose.

variables linked to QoL, and analyzing students' perceptions of these issues. By focusing on agriculture students, this research not only contributes to the broader understanding of food insecurity in higher education but also provides insights that can inform targeted interventions and policies to enhance their well-being and academic success.

Theoretical Framework

This study is focused on Maslow's hierarchy of needs (MHoN), which provides a framework for understanding how access to basic necessities, particularly food, may influence students' quality of life and academic success. The following sections describe the hierarchy and explain the connections between food access and quality of life as it relates to this study.

Maslow's Hierarchy of Needs

Abraham Maslow (1943) conceptualized MHoN, that suggests that individuals generally must satisfy lower-level needs before progressing to higher levels. These five levels include physiological needs, safety, belongingness and love, esteem, and self-actualization. However, more recent research indicates that this hierarchy is not as rigid as originally proposed, with individuals sometimes pursuing higher-level needs even when lower-level ones are not fully met (McLeod, 2026).

Physiological needs, including food, water, rest, clothing, shelter, and reproduction, form the foundation of the hierarchy. If these basic needs are unmet, individuals may struggle to focus on higher-level needs, such as safety or belonging, as their primary concern is fulfilling fundamental survival requirements (Maslow, 1943; McLeod, 2026).

Food Access, QoL, MHoN, and Student Success

Food access, QoL, and MHoN are mutually connected and collectively influence a student's academic success. According to Maslow (1943), physiological needs, such as food, are foundational to higher-level needs. If these basic needs are not met, students may struggle to achieve personal growth or academic success. Food is a critical component of the physiological needs level of MHoN; without adequate access to food, students are less likely to meet this essential need, which can negatively impact their QoL (McLeod, 2026).

Students experiencing food insecurity are likely to prioritize meeting their physiological needs over academic achievement as they focus on obtaining food to survive. This disruption in fulfilling basic needs may compromise their overall well-being, leading to a lower QoL. Research has shown that unmet basic needs, such as food insecurity, are linked to poor academic performance and emotional distress (Ansorger, 2021). In contrast, students with reliable access to nutritious food are better equipped to meet their physiological needs, which enhances their QoL and enables them to focus on higher-level academic and personal goals (Braveman et al., 2011). Therefore, ensuring food access plays a critical role in fostering academic success by supporting students' QoL and helping them meet the foundational needs of Maslow's hierarchy (Ansorger, 2021; McLeod, 2026).

Methods

This study used a mixed-methods approach to explore the impact of food access on the QoL of students in the College of Agriculture and Life Sciences at Virginia Tech. As seen in Figure 1, the design followed a multilevel structure with both concurrent and sequential data collection (Creamer, 2018), allowing quantitative and qualitative data to be collected, compared, and integrated. This approach supported a comprehensive examination of food access conditions, group differences, and students' lived experiences as they relate to QoL.

The objectives of this study were to:

- assess food access among first-generation, international, rural, and urban students.
- examine the relationship between food access and quality of life across physical, psychological, social, and environmental domains.
- compare food access and QoL outcomes across first-generation, international, rural, and urban student groups.
- integrate quantitative and qualitative findings to better understand how food access influences students' overall QoL and lived experiences.

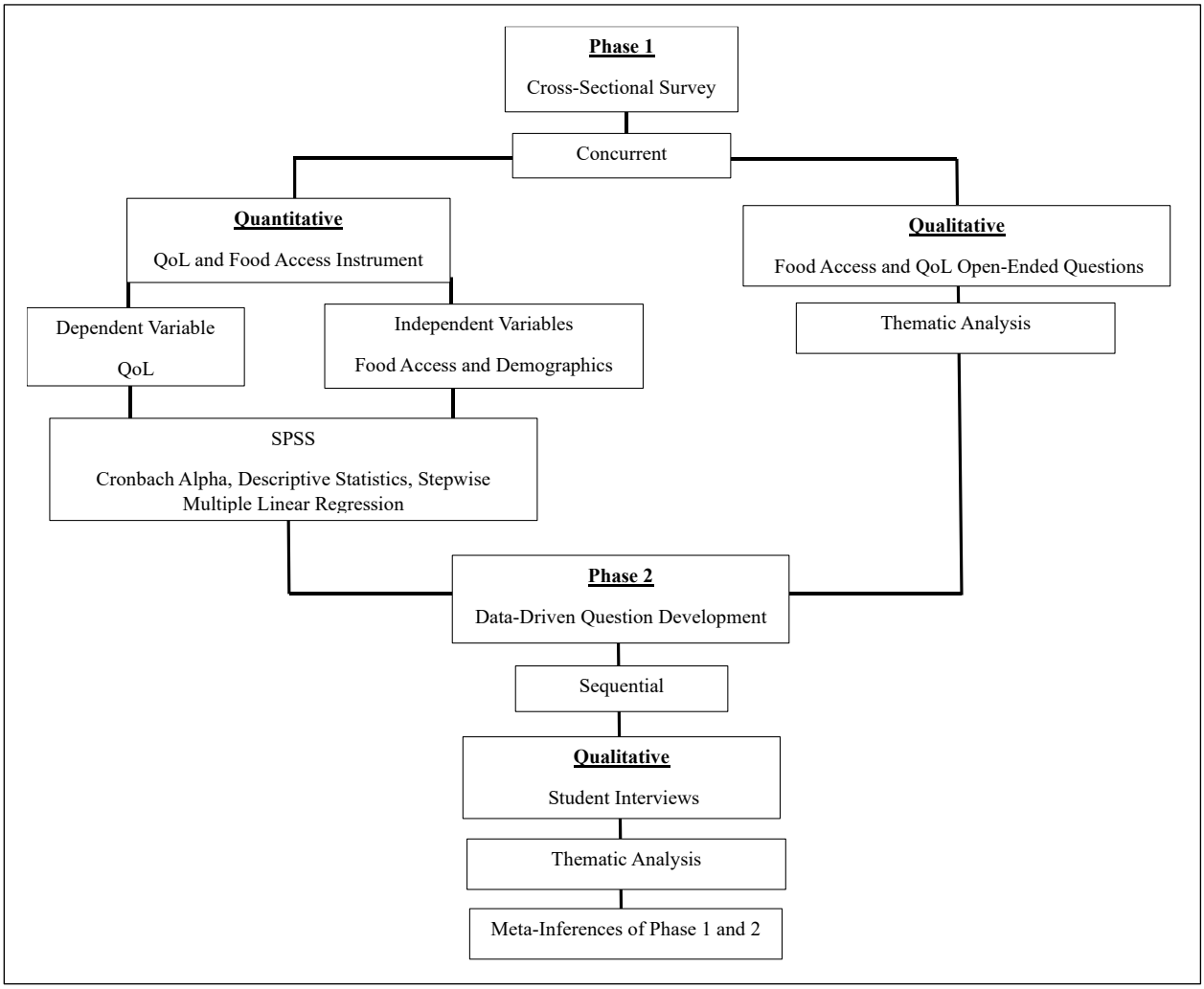
Phase 1: Survey

The first phase utilized a cross-sectional online survey administered through QuestionPro. The survey incorporated quantitative questions, including 11 demographic items, 6 food access questions, and 25 WHOQOL-BREF items, as well as 8 open-ended qualitative questions that explored students' experiences with food access and well-being (Creswell & Creswell, 2018). Skip logic was used to ensure participants only received questions relevant to their experiences. A random single-stage sampling approach was used to invite all Virginia Tech students via the university's email and through classroom recruitment. Prior to distribution, a pilot test with four students ensured clarity and functionality. The final survey remained open for three weeks, and students could volunteer for a follow-up interview by submitting their contact information.

Phase 2: Interviews

Phase 2 expanded upon survey findings through semi-structured Zoom interviews with students who had expressed interest in participating after completing the survey. The first 19 volunteers were selected to represent different backgrounds, including first-generation, international, rural, and urban experiences. Each interview lasted 45–60 minutes and explored emerging survey themes in greater depth. Participants provided consent to be recorded, and the data were securely stored in a protected Google Drive accessible only to the IRB-

Figure 1. Mixed Methods Data Analytic Procedure



approved research team. Interviews continued until data saturation was reached (Hennink et al., 2017).

Data Integration and Analysis

Quantitative data were analyzed using SPSS for descriptive statistics, reliability testing (Cronbach's Alpha), and regression modeling. A forward stepwise multiple linear regression was conducted with QoL as the dependent variable. Stepwise regression was selected to identify the most influential predictors among several demographic and contextual factors, given the exploratory nature of the study and limited prior research on this population. Qualitative responses were coded and analyzed thematically using QuestionPro. Findings from Phase 1 were used to develop interview questions for Phase 2. After interviews were held and analyzed through Reduct, meta-inference (Teddlie & Tashakkori, 2011) was used to reveal how statistical patterns aligned with students lived experiences, offering a view of how food access shapes QoL within the Virginia Tech community.

Results

Phase 1

A cross-sectional survey was distributed to 3,336 undergraduate students in the College of Agriculture and Life Sciences at Virginia Tech, with 809 responses (24% response rate). The QoL scale demonstrated excellent reliability (a = .917), and the food access scale showed acceptable reliability (a = .694).

A stepwise multiple linear regression in SPSS (entry $p \leq .05$; removal $p \geq .10$) identified predictors of QoL. The overall model, as seen in Table 1, was significant (p = .017, adjusted R^2 = .277), explaining 27.7% of the variance. Significant predictors included food access (β = .480, p < .001), Asian identity (β = −.109, p < .001), first-generation status (β = −.109, p < .001), and senior standing (β = .071, p = .017), with food access as the strongest predictor. Departmental models were also significant (adjusted R^2 = .244–.366), with food access consistently predicting QoL. Other predictors varied by group, but food access remained the only variable significant across all models.

Qualitative Survey

Analysis of responses to the eight open-ended questions reinforced the quantitative findings. A dominant theme was the lack of awareness of food resources available both on and off campus. Approximately 64% of respondents reported being unaware of food support services, and nearly half (49%) were unfamiliar with university or community-based programs. Students identified barriers such as schedule conflicts (39%), academic demands (24%), employment commitments (22%), and financial constraints (18%) as limiting access to adequate food. Moreover, 35% reported negative effects linked to food insecurity, including psychological distress (14%), body image concerns (13%), and difficulty concentrating (12%).

The qualitative insights contextualize the regression findings, illustrating how limited food access not only statistically predicts a lower quality of life but also manifests in students' lived experiences through emotional, cognitive, and behavioral challenges.

Table 1. Stepwise Multiple Linear Regression Predicting Quality of Life (QoL)

Predictor	B	SE	β	t	p
Constant	0.930	0.024	—	38.96	< .001
Food Access	0.109	0.007	0.480	16.08	< .001
Asian	−0.049	0.013	−0.109	−3.67	< .001
First-Generation	−0.041	0.011	−0.109	−3.65	< .001
Undergraduate (Senior)	0.030	0.013	0.071	2.40	.017

Note: N = 809. Dependent variable = Quality of Life (QoL). Model statistics: R = .530, R^2 = .281, Adjusted R^2 = .277, F(1, 821) = 5.77, p = .017. Stepwise regression (entry $p \leq .05$, removal $p \geq .10$). β = standardized coefficient.

Phase 2

A total of 19 interviews were conducted to achieve data saturation. The participants represented a diverse demographic profile, including first-generation college students, international students, and individuals from both rural and urban areas. Among the participants, 12 identified as coming from urban areas and four from rural areas. Additionally, six students were first-generation college attendees, and three were international students.

Lack of Awareness

One prevalent theme across both phases was the lack of awareness among students regarding available support programs. Several students shared their frustrations about the lack of information and resources. One student recalled only discovering a helpful program through a friend's recommendation, stating,

> I honestly don't see a lot of programs or anything like that. I know last year I got an email. Actually I didn't even get an email. One of my friends told me about the market, and he like sent a thing you know to sign up for it, and I actually did that last school year, and it was, it was pretty good. But like that, how come I didn't get it, you know, an email? Like why didn't I get that information, and why did he have to tell me about it? So there are things like things like that. I feel like people, like the information isn't out there. I guess you have to go looking for it. I feel like they talk about all the other support except like the food.

Another student echoed this sentiment, emphasizing the difficulty in accessing support due to perceived stigma and fear of judgment. While some students were aware of their own experiences with food insecurity, they often lacked knowledge of the programs and services available to assist them. One participant, for instance, highlighted the societal stigma surrounding food insecurity, noting that many students are hesitant to speak up about their struggles. These accounts suggest that, beyond personal discomfort or shame, a significant barrier lies in the limited awareness of existing campus resources designed to address food insecurity.

Quality of Life

The survey established a link between food access and QoL through multiple linear regression analysis. Students' open-ended responses further illuminated the multifaceted impact of food access on different aspects of their lives. Concerns about the affordability of groceries led to anxiety, which affected emotional health and resulted in persistent worry about financial stability. Physically, students experienced fatigue and difficulty concentrating when meals were insufficient. One student explained: "Yes, I feel extremely tired most days, especially when I haven't eaten enough that day. And it is hard to get through classes, work, and then homework at the end of the night."

Limitations in food access caused strained relationships and social isolation, as the following quote shows:

> Yes, I constantly make excuses not to hang out with some of my colleagues because I don't have the funds to eat out. When I do hang out with them at restaurants, or food places, I'm constantly calculating to the cent of how much the food will impact my overall ability to stay out of debt.

In addition to strained relationships and isolation, students felt embarrassed or excluded from social events due to financial constraints.

During the interviews, participants expanded on the survey findings, emphasizing the direct correlation between food access and physical and psychological well-being. Physical symptoms of hunger, such as lethargy and concentration difficulties, were commonly reported: "So during lunch, like if I don't have lunch, I physically like crumble and like I cannot concentrate whatsoever."

In addition to this quote on physical health, a student addressed the stress of having enough funds to support their family, stating, "So now, credit card [bill] is on the roof. Last year, I was going to donate plasma to get some extra income just to pay a couple of bills. So this is something that I did for a couple of months. And I probably need to do it again."

Being an international student with dietary restrictions played a significant role in facing chal-

lenges in accessing familiar foods and adjusting to the availability of suitable food. One international student stated,

> Internationals in general have a little bit more struggle. I think it's because of where we are, like as a campus so we're definitely on a mountain like kinda in the middle of nowhere so it's, it makes it difficult to access, especially I love seafood, but like over here we have just frozen seafood, we don't have good quality seafood at all, and like if we want some better food we have to drive to Rona, which is 45 minutes away, and we cannot do that every day.

A student with a gluten allergy explained the health issues they faced because of a lack of access to gluten-free foods, stating,

> So with the allergy-based access, I'd say yes, definitely physical. I've seen a bunch of doctors over winter break about some issues that I've had recently that are likely related to nutrition and likely related to not being able to afford healthier food because I'm gluten-free.

Environmental barriers, including class schedules, transportation limitations, and geographical location, further compounded food access challenges, hindering students' ability to obtain nutritious meals. As noted in the survey, students discussed how their social relationships were affected during the interviews. One student wouldn't attend social events or hang out with friends due to low funds to spend on food, and said, "At some point, I was not attending any social events and not going out with my friends, because I was embarrassed that I would not be able to pay for food (among other things)."

The students' perspectives shed light on the complex relationship between food access and students' quality of life while in school. The findings underscore the significance of establishing support networks to help students overcome the barriers to food access that they encounter.

Meal Plan Money

Several students shared their perspectives on the issue of running out of their meal plan funds. One interviewee described the frequent occurrence of running out of meal plan money during the stressful period of final exams, saying, "Yep, every time. It's always like a month before when you're in the middle of final season, just like, okay."

One interviewee emphasized the need to seek support from family members when facing the challenge of limited dining dollars, saying,

> I have to text my mom every so often and be like, "Hey mom, I'm running outta dining dollars." Um, and she's like, "What are you eating?" And I'm like, "I'm literally only eating like two meals a day out."

One student had extra money during their first year, but eventually had to cut back to one meal a day due to financial constraints. The student said, "My freshman year when I had a meal plan on campus. I actually had a big surplus of money, and … I had the minimum one, but I just like would only have like one meal a day."

These perspectives underscore the importance of implementing comprehensive support mechanisms to ensure students' access to essential resources and alleviate financial burdens, fostering a conducive environment for their academic success and well-being.

Virginia Tech Support

Several students have expressed concerns about the lack of recognition of food access issues on campus. One student emphasized the importance of raising awareness and creating solidarity within the community and campus to tackle the issue, likening it to the strides made for diversity and inclusion, stating,

> I think the number one is acknowledge there is the issue. That's the number one, they need to make it aware, the same way they do with the diversity inclusion. They need to … give the same visibility, give you awareness, and create more solidarity to be a community, more solidarity or more sensitive to this matter. Like for

> example, it's not always the answer, is not always putting money on something.

Another student desired change, underscoring the importance of gathering perspectives from those most affected by the issue, saying,

> I don't really know any like resources that's like kind of why I wanted to do this interview was like, just kind of, I don't know, like I do want to see change, so I was like, I don't know, I think it's important to get input from like the people who are actually like affected by it. But I don't, there aren't really any like resources besides the market that I know of, and that's like for people who, like, are like food insecure and like do need access to more ready. But, yeah, there needs to be a lot of change.

Meanwhile, one student emphasized the importance of offering healthy food options, particularly given the campus's reputation for poor nutrition. The student said,

> Giving students food that's not healthy, [I] feel like there needs to be some focus on what are we actually selling to students on campus. If we're a huge nutrition campus, which we are, and you know one of our, our campus is considered to have the best food.

Lastly, in one interview with a student, they recounted personal experiences of feeling unheard, mainly regarding dietary needs, citing instances where essential food options were unavailable due to operational issues and a lack of communication from dining services. The student expressed,

> Chick-fil-A that's in Virginia Tech Grill, they, when they're understaffed, they stop making all grilled items. So if you're gluten free and they're not making grilled items, I simply can't eat there. And like that information is not posted anywhere. So a lot of times I'll show up expecting to be able to get my grilled chicken and be on my way. I asked to speak with the manager at one time that I was there and they directed me to have an email conversation. So I was emailing back and forth with someone from dining and they were explaining that because of the understaffing, they decided that the grilled items were what needed to go. So when I basically wrote back and was like, well, I, there is a whole population of people that now can't eat. Like, how can that be communicated in advance? So and she never responded. So that was unfortunate.

Collectively, these viewpoints suggest that increased attention and action are required to address the challenges surrounding food access and awareness of the issues students face. The recurring themes of lack of acknowledgment, desire for change, and frustration with operational shortcomings within dining services highlight systemic issues that need attention.

Overall, the combined analyses highlight the central role of food access in shaping students' quality of life. Quantitative results identified food access as the strongest predictor, while qualitative narratives revealed the complex emotional, social, and academic challenges associated with food insecurity. Collectively, these findings show the need for institutional initiatives that enhance awareness of food resources, eliminate barriers to access, and foster a supportive campus environment that promotes student success.

Discussion

This study utilized a mixed-method approach to explore the complex issues of food access and its impact on the quality of life among College of Agriculture and Life Sciences students at Virginia Tech. By analyzing cross-sectional survey questions alongside interview data, the objective was to gain deeper insights into the challenges students face in securing their meals. This study aimed to show the unique experiences of agriculture students.

Awareness

One of the major concerns in Phase 1 was the lack of awareness of food resources among students at Virginia Tech. Phase 2 supported Phase 1's findings that students lack awareness of food resources on and off campus. Peterson et al. (2022) and Hagedorn-Hatfield et al. (2022) found that una-

wareness of support was a leading factor in students not accessing resources. If they are unaware of the resources available to them, how can we expect students to utilize them? The stigma surrounding the need for basic support, such as food assistance, has long been a concern, often discouraging individuals from speaking out due to fear of judgment (Duong et al., 2024; Peterson et al., 2022).

Physical Health, Psychological Health, Social Relationships, and Environment

Physical health has been shown to have a significant impact on a student's academic success (Martinez et al., 2019). If a student is not consuming the amount of food necessary to complete daily tasks, their energy levels will be affected (Taras, 2005). In this study, students voiced feelings of fatigue, lethargy, and lack of motivation to participate in daily activities. Food access was shown to affect college students' psychological health negatively by causing added stress, depression, and lack of concentration or learning, which has been documented in other studies as well (Maroto, 2013; Pourmotabbed et al., 2020). A person's QoL will be influenced by their psychological health and how they participate in daily living (WHO, 2012).

Meaningful social relationships were important to students who participated in the interviews. According to the literature, having social relationships while in school is an indicator of success for a student and a key component in one's QoL (Jorgenson et al., 2018; Maslow, 1943; WHO, 2012). A student who lacks social connections during school could potentially drop out. Connecting with friends, family, mentors, leadership, faculty, and staff can help students navigate the hardships they may face. Higher education institutions recognize the importance of social connections for students while they are in school. The ability to "lean" on someone during instances of difficulties has been shown to increase the likelihood of a student staying in school (Schmidt, 2020; Stadtfeld et al., 2019).

Additionally, as voiced in the interviews, the environment in which one lives impacts food access (Mockshell & Villarino, 2019; Ogot, 2021). A student's environment influences the quantity and quality of food available and accessible to them. If students do not have access to the foods they want and need, their QoL can be impacted (Frongillo et al., 2017; Hanmer et al., 2021; Sok et al., 2018).

Running Out of Meal Plan Money

A theme not mentioned in the survey was running out of meal plan money. Students participating in the interviews discussed concerns about running out of meal plan money. Of the 19 students who participated in the interviews, 15 had meal plans, and 11 had exhausted their meal plan funds at some point during their college career. When interviewed, the two students who didn't run out of meals mentioned having only two or fewer meals daily. Other students would put more money into their meal plan if they could afford it. Students who exhausted their meal plans and lacked the financial means to add additional funds were compelled to subsist on minimal food resources for the remainder of the semester, often skipping meals or relying on inexpensive, low-nutrient options.

The University Acknowledging Food Access Concerns

Another theme that students brought to attention in the interviews was the concern that food access issues are not being acknowledged on campus or by leadership. Hall et al. (2019) found that food insecurity exists on campus at Virginia Tech, while The Hope Center (2021) has been researching food insecurity on college campuses nationwide from 2015 to 2021. Although food access and food insecurity are distinct yet interrelated concepts, limited access to affordable and nutritious food options on campus contributes to an increased prevalence of food insecurity among students. Current university resources remain insufficient to address the scope of this issue (Tanner et al., 2023). Additionally, college and university leadership may not be addressing food access concerns due to other competing priorities that also factor in. Taylor et al. (2021) surveyed 348 college and university presidents in the spring of 2021 and asked them to identify the most pressing issue. The top three matters identified by presidents were the mental health of students (72%), the mental health of faculty and staff (58%), and long-term financial viability (41%), while food and

housing insecurity ranked 13th out of 19 issues (15%). Mental health is an important issue to address on campus, but so is access to food. This research highlights the importance of food access and its impact on one's psychological health. Glantsman et al. (2022) stated, "Adequate food and housing are essential to college students' general well-being and academic achievement."

Recommendations

College students are often perceived as privileged in society; however, that doesn't mean they don't face barriers to accessing food. Higher education institutions, such as Virginia Tech, can provide a space for students to break down these barriers and help prevent them from going hungry. The following are recommendations based on the results of this study.

Tailored Support Programs: Developing customized support programs to assist first-generation, international, rural, and urban students in agriculture can improve food access for these groups. Programs should consider the distinctive obstacles faced by these student groups when accessing food and offer personalized solutions and resources.

Financial Support for Meal Plans: Investigating ways to offer financial support, such as scholarships or free meal plans, to students who often run out of their meal plan funds could offset food access concerns. Additionally, schools can increase meal plan allowances or provide emergency meal vouchers to students in need who are running low on meal plan funds during the semester.

Improving Campus Food Options: Enhancing the range of dietary choices accessible on campus to meet the diverse dietary requirements and preferences of students, such as those who require gluten-free, vegan, and allergen-free options, is needed. Schools can collaborate with higher education leadership, dining and nutrition professionals, and students to create options that cater to various dietary needs.

Building Collaborative Relationships: Encouraging partnerships between campus student groups, school leadership, dining services, academic departments, and campus support centers to address food access concerns can alleviate students' burdens. Facilitating conversations to raise awareness, provide support, and advocate for systemic changes can enhance food access and improve the quality of life for all students.

Limitations

This study has limitations to be considered when interpreting the findings of this study. Most notably, the sample was drawn from a single institution. It was limited to students within the College of Agriculture and Life Sciences at Virginia Tech, which constrains the results to a broader student population or institutional outlooks. The reliance on self-reported data also introduces the possibility of recall error and bias, particularly given the stigma surrounding food insecurity and food access concerns on a university campus. Furthermore, although the qualitative component provided valuable depth, the sample size (n = 19) may not fully capture student experiences, especially among smaller or underrepresented subgroups.

Conclusion

Research consistently demonstrates that food insecurity is a significant and widespread issue on college campuses (Broton et al., 2020; Goldrick-Rab et al., 2017; Hall et al., 2019; Leung et al., 2021; Martinez et al., 2019; Regan, 2020). This mixed-methods study contributes to that body of knowledge by showing that agricultural students at Virginia Tech face multiple interconnected barriers to securing adequate food. Students reported frequently running out of meal plan funds, being unaware of available on- and off-campus food resources, and experiencing negative impacts on their physical health, psychological well-being, academic performance, and social relationships. They also expressed a clear desire for institutional recognition of food access challenges and for more robust, visible support systems.

The findings demonstrate that food access is not a secondary concern; it is a core determinant of students' overall quality of life and academic persistence. Colleges and universities cannot expect to retain and graduate students if basic needs remain unmet. Addressing food access barriers must therefore be treated as an institutional priority, not an optional initiative. This requires proactive outreach, transparent communication about resources, im-

plementation of targeted support programs, and engagement with student experiences.

Meaningful progress will occur only when higher education leadership listens to students, acknowledges the scope of the problem, and commits to sustained, systemic action. Ensuring reliable access to food is not simply supplemental support; rather, it is a fundamental condition for student well-being, academic achievement, and long-term success.

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Appendices

Appendix A. Student Survey

Survey Summary
o The objective of this survey is to examine how food access has an impact on the quality of life of College of Agriculture and Life Science students.
o The survey will take ~10 minutes to complete.
o Your responses to the survey will remain anonymous.
o If you have questions, concerns, or complaints or think the research has hurt you, talk to the research team at lanap20@vt.edu.

This research has been reviewed and approved by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at 540-231-3732 or irb@vt.edu if:
o You have questions about your rights as a research subject
o Your questions, concerns, or complaints are not being answered by the research team
o You cannot reach the research team
o You want to talk to someone besides the research team to provide feedback about this research

By selecting yes below, you indicate your consent to participate in this research study. Do you agree to participate in the study?

Yes

No

Q2

Are you 18 years or older?

Yes

No

Q3

Are you a student in the College of Agriculture and Life Sciences?

Yes

No

Q4

What is your department/school within the College of Agriculture and Life Sciences?

Agricultural and Applied Economics
Agricultural, Leadership, and Community Education
Agricultural Technology Program
Animal and Poultry Sciences
Biochemistry
Biological Systems Engineering
Entomology
Food Science and Technology
Human Nutrition, Foods, and Exercise
School of Plant and Environmental Sciences
Dairy Science
Other

Q5

What degree are you currently seeking?

Undergraduate
Graduate (M.S., Ph.D., OMALS)
Associate
Other

Q6

What is your undergraduate status?

Freshman
Sophomore
Junior
Senior
5th year senior
Other

Q7

What is your graduate status?

M.S.

Ph.D.

OMALS

Other

Q8

How would you identify your race/ethnicity? (Select all that applies)

American Indian or Alaskan Native

Asian

Black or African American

Caribbean

Hispanic or Latino

Middle Eastern or North African

Native Hawaiian or Pacific Islander

White or Caucasian

Self-identify as another race/ethnicity

Q9

What is your living situation?

On-campus

Off-campus

No housing or couch surfing

Q10

Are you a first-generation student? (Someone who is first in their family to go to college)

Yes

No

Don't know

Q11

Are you an international student?

Yes

No

Don't know

Q12

How would you classify the geographic location where you grew up?

Rural area

Urban area

Don't know

Q13

What is your current overall GPA?

Multiple Row Answer text

Q14

This assessment asks how you feel about your quality of life, health, or other areas of your life. Please answer all the questions. If you are unsure about which response to give to a question, please choose the one that appears most appropriate. This can often be your first response.

Q15

Question Text

	Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
How would you rate your quality of life?	○	○	○	○	○
How satisfied are you with your health?	○	○	○	○	○

Q16

Question Text

	Not at all	A little	A moderate amount	Very much	Extremely
To what extent do you feel that (physical) pain prevents you from doing what you need to do?	○	○	○	○	○
How much do you need medical treatment to function in your daily life?	○	○	○	○	○
How much do you enjoy life?	○	○	○	○	○
To what extent do you feel your life to be meaningful?	○	○	○	○	○

Q17

Question Text

	Not at all	A little	A moderate amount	Very much	Extremely
How well are you able to concentrate?	○	○	○	○	○
How safe do you feel in your daily life?	○	○	○	○	○
How healthy is your physical environment?	○	○	○	○	○
Do you have enough energy for everyday life?	○	○	○	○	○
Are you able to accept your bodily appearance?	○	○	○	○	○
Do you have enough money to meet your needs?	○	○	○	○	○
How available to you is the information that you need in your day-to-day life?	○	○	○	○	○
To what extent do you have the opportunity for leisure activities?	○	○	○	○	○

Q18

How well are you able to get around?

Very poor

Poor

Neither poor nor good

Good

Very good

Q19

Question Text

	Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
How satisfied are you with your sleep?	○	○	○	○	○
How satisfied are you with your ability to perform your daily living activities?	○	○	○	○	○
How satisfied are you with your capacity for work?	○	○	○	○	○
How satisfied are you with yourself?	○	○	○	○	○
How satisfied are you with your personal relationships?	○	○	○	○	○
How satisfied are you with the support you get from your friends?	○	○	○	○	○
How satisfied are you with the conditions of your living place?	○	○	○	○	○
How satisfied are you with your access to health services?	○	○	○	○	○
How satisfied are you with your transportation?	○	○	○	○	○

Q20

How often do you have negative feelings such as blue mood, despair, anxiety, or depression?

Never

Seldom

Quite often

Very often

Always

Q21

The following questions pertain to food access. If you are unsure which response to give to a question, please choose the one that appears most appropriate.

Q22

Question Text

	Not at all	A little	A moderate amount	Very much	Extremely
Do you have access to the choice of food you want?	○	○	○	○	○
Are you aware of the resources on campus for food assistance?	○	○	○	○	○
Do you have barriers that restrict your access to food?	○	○	○	○	○
How often do you put other expenses before purchasing food?	○	○	○	○	○
Are you able to aquire the amount of food you want?	○	○	○	○	○
Are you aware of the community resources for food assistance?	○	○	○	○	○

Q23

The following questions will allow you to talk about food access in your own words.

Q32

Would you be willing to participate in a follow-up 15-20 minute discussion about the impacts of food access on quality of life? The first 15 interview participants will receive a $33 gift card to Kroger.

Yes

No

Q33

Are you any of the following demographics? (Please select all that apply)

First-generation student

International student

Rural student

Urban student

Q34

Contact Information

First Name

Last Name

Phone

Email Address

Thank you Page

Thank you for taking part in the survey. If you or someone you know is experiencing food access concerns, please use the resources provided.

- The Dean of Students office: The office offers emergency grants that help with issues such as food and housing needs. Contact the team at 540-231-3787 (after-hours number: enter 540-231-6411 then press 1) or dean.students@vt.edu.
- 209 Marketplace at Virginia Tech: VT students can shop for food, toiletries, and school supplies each week at this pantry. While the organization is located inside a Methodist campus ministry, all are welcome. Learn more on their website.
- Interfaith Food Pantry: qualified residents of Blacksburg and McCoy are welcome to shop at this pantry, which is open weekly Monday and Tuesday from 4–6 p.m. and Wednesday and Friday from 10–11:30 a.m.

Appendix B. Interview Questions

Interview Questions

Student Name: _____

Demographics: _____

Date of Interview: _____

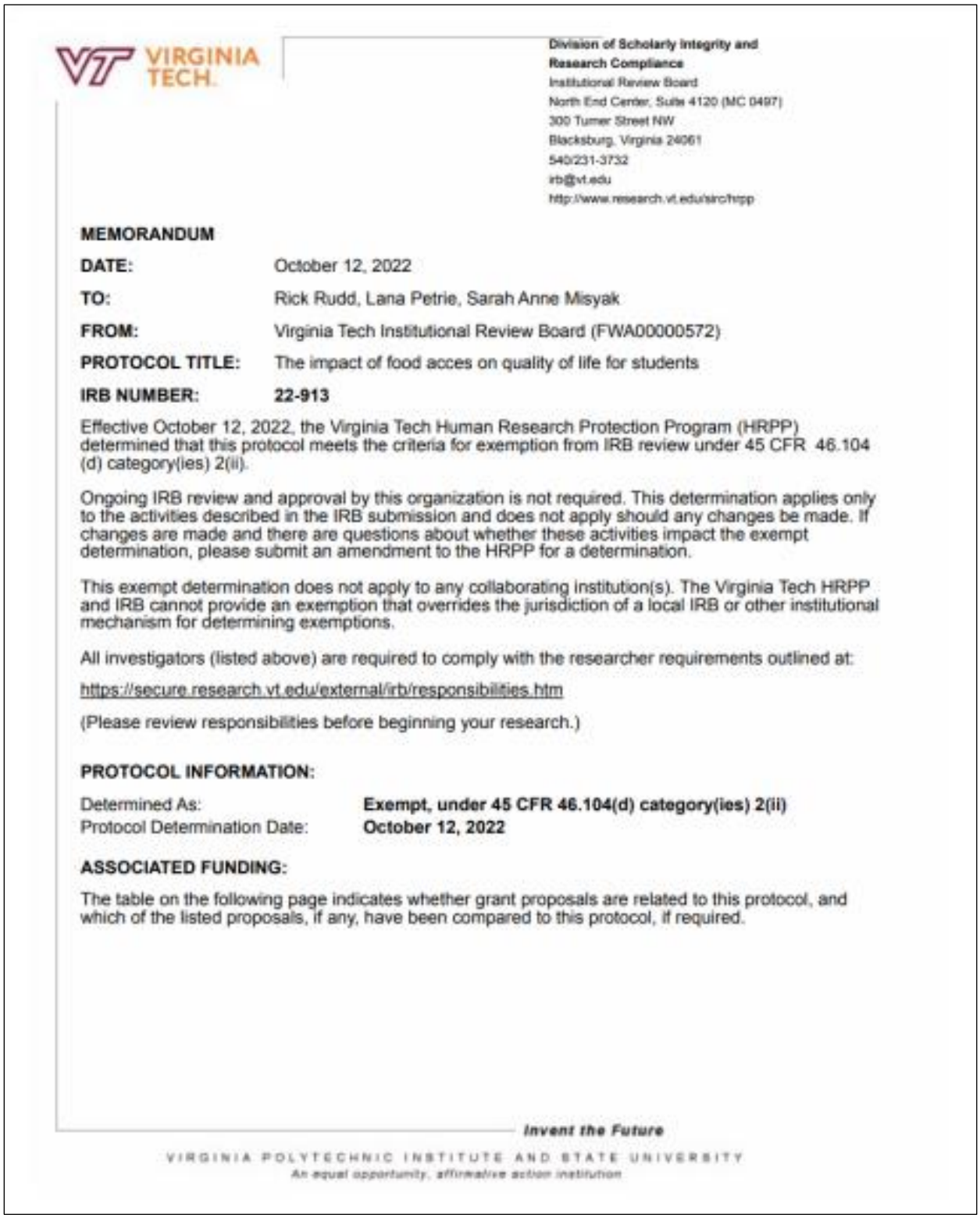
First, I would like to ask you about how access to food impacts your life.

1. How does access to food affect your energy or ability to participate in everyday life activities while in school?
    a. Probes: attending class, studying, grades, receiving academic support, seeing friends, clubs, recreational activities
2. How does money affect your ability to make financial decisions for your basic needs, such as food?
    a. Probes: rent, textbooks, meal plan, childcare
    b. Have you run out of campus meal plan money?
3. How does access to food affect your physical and mental health?
    a. Probes: body image, concentration, stress, depression, weight, sleep
4. How does not having food or being able to purchase food impact your ability to attend social events?
    a. Expand on bringing food to events, going out to eat with friends
5. How does your class schedule determine what and how often you eat in a day?
    a. Probes: Do you skip meals, do you have time to cook, are lines too long, do you have classes back to back

Now, I would like to switch gears a little bit and ask about the resources available on the Virginia Tech campus and what factors impact whether students can access those resources.

6. Have you ever felt comfortable talking with someone about not having access to food? If not, can you explain why?
7. What are your perceptions on why students don't know what resources are available on and off campus?
8. What is the biggest barrier you have to access the amount or types of food you want?
9. In what ways do you think Virginia Tech can support students?
    a. Probe: particularly around food access
    b. At the school, college, and/or department level

Appendix C. Institutional Review Board (IRB) Approval Letter



VIRGINIA TECH

Division of Scholarly Integrity and
Research Compliance
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Blacksburg, Virginia 24061
540/231-3732
irb@vt.edu
http://www.research.vt.edu/sirc/hrpp

MEMORANDUM

DATE: October 12, 2022

TO: Rick Rudd, Lana Petrie, Sarah Anne Misyak

FROM: Virginia Tech Institutional Review Board (FWA00000572)

PROTOCOL TITLE: The impact of food acces on quality of life for students

IRB NUMBER: **22-913**

Effective October 12, 2022, the Virginia Tech Human Research Protection Program (HRPP) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104 (d) category(ies) 2(ii).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit an amendment to the HRPP for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before beginning your research.)

PROTOCOL INFORMATION:

Determined As: **Exempt, under 45 CFR 46.104(d) category(ies) 2(ii)**
Protocol Determination Date: **October 12, 2022**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

Invent the Future

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Understanding college food insecurity through the lens of the theory of planned behavior and social stigma

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Abstract

Intention to use food pantries is a persistent factor in food access among college students, yet how stigma, individual beliefs, and behaviors influence usage remain understudied. This study utilized the theory of planned behavior to examine the relationship between self-perceived stigma, attitudes, normative beliefs, and perceived behavioral control, and their influences on intention to use food pantries. A mixed-methods, 51-item branched survey was administered online to a convenience sample of students (N = 173) at an Appalachian North

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There was no funding to report for this work.

Conflict of Interest
All authors declare no conflicts of interest.

Author Contributions
The responsibilities of the authors are as follows: BEM: analyzed data and refined the manuscript for publication; MR: analyzed data, performed statistical analysis, and refined the manuscript for publication; ARF: analyzed data and refined the manuscript for publication; ATD: designed the study and conducted the project; AEW: contributed to the design of the study, analyzed data, and refined the manuscript for publication.

Carolina state university. Ordinal logistic regression was used to assess the relationship between pantry usage intent and perceived self-stigma, and key theory of planned behavior constructs: Attitudes, Normative Beliefs, and Perceived Behavioral Control. Results showed that higher Normative Belief and Perceived Behavioral Control scores were positively associated with intent to use food pantries. In contrast, higher Self-Stigma scores were inversely related to intent, indicating stigma to be a significant barrier. These findings suggest that increasing communication, accessibility, and normalization of pantry use could improve student food access. Overall, the study highlights how stigma and individual beliefs influence help-seeking behavior among college students, and the importance of methodical dissemination of resources and normalization of such help-seeking behaviors (through empowerment counseling support) to enhance the use of food pantries. Further research should explore similar dynamics in other university settings and evaluate the theory of planned behavior as a framework for understanding food access behaviors.

Keywords
food security, food pantry, implementation, college students, higher education, barriers, stigma

Introduction

Food insecurity, as defined by the U.S. Department of Agriculture, Economic Research Service (USDA ERS), is an economic and social condition of limited or uncertain access to adequate food (n.d.). Certain populations such as immigrants, individuals in the Southern United States, Black, Hispanic, and Asian populations, households with children, children with disabilities, households near or below the poverty line, and single-caregiver households with children, are disproportionately affected by food insecurity (Atoloye et al., 2026; Coleman-Jensen, 2020; Ullmann et al., 2022). Perhaps less visible than these populations, college students also experience challenges accessing an adequate amount of affordable, nutritious food, and show high rates of food insecurity, according to results from the USDA Adult Food Security Survey (AFSS) administered at two-year, four-year, public, and private post-secondary campuses nationwide (Mitchell et al., 2022). Collegiate food insecurity rates have been reported to range from 10–75% (Nikolaus et al., 2020). College student food insecurity is significantly associated with greater mental health concerns (anxiety, stress, depression), poor physical health (Bruening et al., 2018; Farahbakhsh et al., 2017; Hughes et al., 2011; Patton-López et al., 2014), difficulties maintaining academic requirements and/or poor performance, and issues as well with financial management, leading to increased utilization of credit cards, loans, and borrowing money from friends and family (Gaines et al., 2014; Hagedorn et al., 2019; Hege et al., 2021; McArthur et al., 2018; Nikolaus et al., 2020; Wattick et al., 2018).

Some of these physical and mental impacts on health can be addressed by focusing on barriers students must navigate to access resources (Feeding America, n.d.). However, food access and programs like the Supplemental Nutrition Assistance Program for adults may not be consistently available to enrolled college students (Hagedorn-Hatfield, Hood et al., 2022; USDA Food and Nutrition Administration, n.d.). To maintain an adequate food supply and decrease hunger, students report engaging in many coping behaviors such as purchasing cheap foods instead of fruits and vegetables, attending free food events, stretching food to last longer, and relying on external sources of support such as friends, family, or institutions (Fernandez et al., 2021; Mitchell et al., 2022).

In response to the high rates of collegiate food insecurity, implementation of campus food pantries has become widespread to support students (Hagedorn-Hatfield, Richards et al., 2022). However, students in previous research have reported several barriers to utilizing their campus pantries. In one study, students noted a lack of fresh fruits and vegetables but that canned and shelf-stable items were abundant, while they desired more fresh items such as meats, dairy, and bread, and a more consistent quality of food items provided (Brito-Silva et al., 2022). In a systematic review compiling data from eight different studies, multiple points of improvement were noted that increased food pantry usage, like flexibility in accessing food pantries,

such as through an online store, employing friendly staff to help, and creating a positive environment through encouraging notes, would make the food pantry seem more a viable option for college students (Idehai et al., 2024). Other avenues campuses have implemented to assist food insecure students is meal plans or meal swipe sharing. As of 2025, 850 colleges and universities were members of a national meal plan sharing nonprofit, Swipe Out Hunger, dedicated to ending college student hunger. The program redistributes unused meals in a student's meal plan to students reporting food insecurity or students who have run out of meal swipes (Swipe Out Hunger, n.d.). Although meal plans is a method to feed students and prevent food insecurity, students still reported food insecurity while having meals left in their meal plan (van Woerden et al., 2019). These common food assistance resources, although reporting issues, nevertheless present possible ways to aid individuals experiencing college food insecurity and are typically implemented, with college campus food pantries the most common intervention (Hagedorn-Hatfield, Richards et al., 2022). However, current research identifies frequent barriers to consistent utilization, including lack of knowledge or awareness of resources, inconvenient hours of operation or location, transportation difficulties, and social stigma of using food assistance resources (El Zein et al., 2018, 2022; McArthur et al., 2020; Mitchell & Prescott, 2022).

From a sociological perspective, stigma is described as an internalized double perspective for the individual, causing the subject to believe that their stigmatizing difference is immediately noticeable by others, or that this difference is neither noticeable nor perceived (Goffman, 1963). There are multiple forms of stigma. Perceived stigma is described as one's beliefs regarding attitudes that others may hold towards stigmatized populations, specifically something that may be affecting themselves, such as mental illness (Fox et al., 2018). Self-stigma often occurs due to exposure to stigma, thus internalizing negative stereotypes (Waters et al., 2025). Public stigma is the belief that most people hold negative views towards a characteristic, suggests to the subject that everyone believes the negative views that they might have of themselves (Goodwill & Zhou, 2020).

Generally, perceived stigma, public stigma, and self-stigma can all have negative behavioral outcomes for individuals seeking help, and can influence one another. For example, in a mixed-methods study examining perceived and self-stigma among food pantry users and non-users, users had higher self-stigma and blaming behaviors attached to seeking help compared to non-users (Duong et al., 2024). Additionally, food pantry users had significantly higher reports of perceived stigma, that non-users would disapprove of their "inability" to be self-reliant or self-sufficient, compared to non-users and the public (Duong et al., 2024; Kindle et al., 2019). Moreover non-users indicated and identified public stigma or explicit labels or stereotypes including users being poor, weak, or embarrassing (Duong et al., 2024).

Notably, research suggests that public stigma can contribute to an individual's self-stigma for seeking help, including food pantries and food assistance resources (Duong et al., 2024; Latalova et al., 2014). Food pantry stigma involves internalization of negative stereotypes associated with accessing food assistance that may result in shame, embarrassment, fear and possibly underutilization of resources (DeBate et al., 2024; Duong et al., 2024; El Zein et al., 2022; Kindle et al., 2019; Taylor et al., 2024). Research suggests that individuals feel "othered," that they are seen as different or as poor, which can impact self-esteem and lead to students feeling undeserving of support (Duong et al., 2024; El Zein et al., 2022; Peterson et al., 2022; Taylor et al., 2024). College can be seen as a time to be self-sufficient and completely independent from family members, which also contributes to feelings of failure when seeking help (Goldrick-Rab, 2016). Students have also reported anxiety and depression consequent to using food assistance. This may be due to negative stereotypes in society around accessing food resources, feeling internal "shame" for accessing help, feeling that others may need the assistance more, and perceiving themselves as having a lower social status (Bruckner et al., 2021; DeBate et al., 2024; Duong et al., 2024; McArthur et al., 2020; Peterson et al., 2022). To avoid social embar-

rassment among their peers, students stay away from resources (Peterson et al., 2022).

Many factors influence individuals' intentions to use food pantries as well as stigma, including access, information, knowledge, and attitudes. We examine how these factors—such as attitudes, beliefs, social norms, stereotypes, and self-stigma—relate to the intention to use food pantries among college students and build upon previous research conducted at similar universities (Duong et al., 2024; McArthur et al., 2020). To our knowledge, current research does not employ theoretical frameworks such as the theory of planned behavior (TPB) to understand what influences the decision to use food pantries. This approach could shed light on participants' attitudes, self-stigma, knowledge, beliefs, and social norms and social stereotypes, thereby guiding more targeted implementation of campus resources. The purpose of this study was to assess how constructs from the TPB (attitudes, normative beliefs, and perceived behavioral control) might affect the intention to use campus food pantries among participants, specifically among individuals experiencing food insecurity who have not used the pantries. Additionally, this study aimed to explore how self-stigma influences access to pantries in this population. This research may provide useful insights and support to campus administrations, with the goal of increasing food pantry utilization.

Methods

This study was approved by the Appalachian State University Institutional Review Board (protocol number: HS-23-164).

Theoretical Framework

The TPB was developed by Icek Ajzen (1985) to predict human behavior through intention. The theory suggests that attitude—positive and negative thoughts about behavior—toward a behavior, normative beliefs about the behavior (the social pressures or influences someone has about the behavior), and perceived control (ability [i.e., knowledge and autonomy] and knowledge of their capacity to perform the behavior) over that behavior are all predictors of intention to do the behavior.

Study Location and Recruitment

The study location is a residential state university in rural Appalachian North Carolina with an average of 21,000 students. Most of the student body identifies as female (57.5%) and around 15,000 live off campus. The Institutional Research, Assessment, and Planning Office (IRAP) reports that about 19% of the students are from underrepresented groups. Each academic year (first year to fourth year) holds about a quarter (20–26%) of the student population.

Initial email recruitment was conducted by the IRAP on Wednesday, January 25, 2023, utilizing a randomly selected, computer-generated student email list of 3,000 emails for potential recruitment, with three follow-up emails sent each Wednesday following the initial email. Along with the email recruitment, QR code flyers were posted at three on-campus food pantries. To be eligible to participate in this study, one had to be at least 18, and an enrolled student at Appalachian State University.

Study Design

The reported results in this paper are a subset of measures that were a part of a larger, mixed-methods survey (see supplementary material for a description of the entire survey measures) to provide more understanding of barriers to campus food pantry use. The Qualtrics survey was a branched survey with 51 questions in each of two versions. Each version of the survey was informed by previous food pantry stigma and food insecurity research (Kindle et al., 2019; Vogel et al., 2006). Both surveys began with an informed consent document that required participants to read and respond "yes" or "no" to participate in the study. Participants then self-selected by answering the next survey question, "Have you used a food pantry at Appalachian State University?" This question categorized the participants into two separate surveys. One version was completed by individuals who self-identified as not using the campus food pantry, and the second version was completed by participants who self-identified as food pantry users. All participants were asked a qualitative data question: "Do you believe that there is stigma surrounding food pantry users? Why or why not?"

Qualitative findings from this study have been published (Duong et al., 2024).

Study Measures, Survey Design, and Analysis of Measurements

The surveys included validated scales such as the 10-item USDA Food Security Scale for Use with Colleges Students, the 10-item food pantry self-stigma measure, an adapted 10-item version of the Self-Stigma of Seeking Help (SSOSH) tool, an 11-item assessment of the theory of planned behavior constructs, and demographic questions on gender, race, year in school, use of a meal plan, employment, and on or off campus housing (Ajzen, 2006; Ames & Barnett, 2019; Kindle et al., 2019; Vogel et al., 2006). Examples of survey questions and measurements are included in the supplementary material.

Food Security Measure and Analysis

The 10-item USDA Food Security screener was used to categorize participants as food secure or food insecure (Coleman-Jensen et al., 2013). Completed responses were scored based on affirming responses ("yes," "often," "sometimes," "every month," and "some months but not every month") and non- affirming responses to create a categorical variable. For example, participants were asked: "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more," "Was that often, sometimes, or never true for (you/your household) in the last 12 months?" For analysis, respondents with a score of 0–2 were categorized as food secure and those with a score of 3–10 were categorized as food insecure.

Food Pantry Use and Food Security Measure and Analysis

To study the relationship between food pantry use and food security status, responses were organized into four categories by aligning USDA food security scores and the self-reported (yes or no) food pantry use responses ("Have you used a food pantry at Appalachian State University?"). Categories included (a) food insecure and food pantry use; (b) food secure and food pantry use; (c) food insecure and food pantry nonuse; and (d) food secure and food pantry nonuse. This study will report the findings from the food insecure and food pantry nonuse participant category.

SSOSH Measure and Analysis

To comprehend the experiences of self-stigma toward seeking help (specifically, using campus food pantries), we adapted the 10-item SSOSH questionnaire (Vogel et al., 2006). For example, in the original questionnaire individuals were responding to self-stigma of seeking psychological professional help. We adjusted the items to better reflect self-stigma for seeking food assistance resources, such as "I feel inadequate for using the food pantry for assistance." Participants responded to ten 5-point Likert scale questions with strongly disagree = 1 to strongly agree = 5. Items were coded in accordance with the validated questionnaire (Vogel et al., 2006). Individual responses were summed for an overall SSOSH score (ranging 10–50) with a higher score suggesting that the subject feels more self-stigma for seeking help.

Food Pantry Self-Stigma Measure and Analysis

The Food Pantry Self-Stigma validated survey tool investigates perceived stigma and social distancing between users and non-users of food pantries (Kindle et al., 2019). Participants respond to 10-item, 5-point Likert scale questions (1 = strongly disagree and 5 = strongly agree). For example, "I work hard to keep that I use a food pantry from others" is directly from the validated tool (Kindle et al., 2019). The non-user participants' questions were adapted to reflect a possible public stigma ("I want others to work hard to keep their food pantry use from others/myself") to understand public support or distance, and involve similar terminology changes from previous work (Kindle et al., 2019). Individual responses were coded and summed for an overall score ranging 10–50, with a higher score indicating self-stigma (users) or public stigma (non-users) towards pantry use (Kindle et al., 2019).

Theory of Planned Behavior Measures and Analysis

Theory of planned behavior constructs (i.e. attitudes, normative beliefs [subjective, descriptive, injunctive], perceived behavioral control and inten-

tion to use) were measured by utilizing validated theory of planned behavior survey tools and measurements (Francis et al., 2004). Eleven items directly measured each construct using either 7-point Likert scales (1 = strongly disagree, 7 = strongly agree) or 7-point bipolar adjective scales. For example, to determine the individual's overall attitude towards the food pantry, participants responded to the question: "Using the on-campus food pantries is…" Response categories varied from unhelpful to helpful, bad to good, pleasant to unpleasant, embarrassing to soothing, unimportant to important, and burdensome to easy. Intention to use was measured using the theory of planned behavior–based 7-point Likert scale question (1 = strongly disagree, 7 = strongly agree): "I intend to use the on-campus food pantries when I want to and/or need to."

For the purpose of analysis, survey responses for attitudes, normative beliefs, and perceived behavioral control were summed for an overall score, with higher scores indicating more positive attitudes towards food pantry use (possible scores ranging 6–42), higher perceived behavioral control in confidence and choice in using food pantries (scores ranging 2–14), and greater social support and normative beliefs surrounding food pantry use (scores ranging 2–14). However, for intention to use the food pantry, based on the distribution of the original scores (scores ranging 1–7), it was decided to analyze the variable categorically. Therefore, intention to use was grouped into three categories: weak intention (scores 1–5, coded as 1), agreeable intention (scores of 6, coded as 2) and strong intention (scores of 7, coded as 3). This new definition of the dependent variable was used for further statistical analysis.

Demographic Measures and Analysis

The demographic characteristics included in the survey were gender and race of the respondents, their meal plans, the year of college they were in, their employment status, and their location. Race was coded as White if the reported race was either Caucasian, or White not Hispanic, or White non-Hispanic. Other races including African American, Asian, Hispanic or Latino, and Mixed were coded respective to the response as well as all other reported demographic characteristics.

Statistical Analysis

Because of the ordered nature (categorical) of the dependent variable, we used an ordered logistic regression to assess the association of respondents' intention with Attitudes Score, Normative Belief Score, Perceived Behavioral Control Score, Self-Stigma Score, Self-Stigma of Seeking Help Score, their gender, race, year in college, employment status, and meal plan in college. Given the number of respondents who missed data across various predictors, the regression analysis just uses 137 observations to reflect the completed responses. All analyses were conducted using version 18 of Stata Statistical Software. Additionally, descriptive statistics including means and frequencies were reported.

Results

Table 1 shows the demographic characteristics and distribution, which are comparable to the demographics of the university described in the study location and recruitment. Most respondents were female (62.43%) while about 27% were male. Most respondents were White (84.38%) while about 7% reported mixed race. The respondents were evenly distributed among individuals within their first to fourth year of college, with the most in Year 3 (26%). Most reported not having an on-campus meal plan (59.54%), selected off-campus housing as their living situation (57.23%), and 54.91% reported working one or more part-time jobs. Table 2 presents the descriptive statistics for the dependent and independent variables. The mean of the dependent variable, intention to use food pantries, is 1.71, indicating weak to agreeable intention. For the independent variables, the mean Normative Belief Score is 11.93, the mean Perceived Behavioral Control Score is 11.43, the mean Self-Stigma Score is 17.79, and the mean Self-Stigma of Seeking Help Score is 25.89.

Table 3 presents the results from the ordinal logistic regression in terms of Odds Ratios (OR) (Cameron et al., 2014). An OR greater than one indicates a positive association between an independent variable and intention. An OR less than

Table 1. Distribution of Demographic Characteristics

Characteristics	*N*	%
Gender	**173**	**100**
Male	46	26.59
Female	108	62.43
Non-binary/Third Gender	18	10.40
Prefer not to say	1	0.58
Race	**160**	**100**
White	135	84.38
African American	7	4.38
Asian	1	0.62
Hispanic	6	3.75
Mixed	11	6.88
Year in undergraduate program	**173**	**100**
First year	38	21.97
Second year	44	25.43
Third year	45	26.01
Fourth year	37	21.39
Fifth year or more	9	5.20
Meal Plan	**173**	**100**
Yes	70	40.46
No	103	59.54
Location	**173**	**100**
On-campus	72	41.62
Off-campus	99	57.23
Other	2	1.16
Employment	**173**	**100**
Unemployed	73	42.20
One or more part-time jobs	95	54.91
One full-time job	5	2.89

one indicates a negative association between an independent variable and intention. The only three significant predictor scores are Normative Belief, Perceived Behavioral Control, and Self-Stigma of Seeking Help, with OR = 1.332 ($p < 0.05$), 2.814 ($p < 0.01$), and 0.921 ($p < 0.01$). This means that for a unit increase in Normative Belief Score, the odds of intent to use the food pantry increases by a factor of 1.33. Similarly, for every unit increase in the Perceived Behavioral Control Score, the odds of Intent increase by a factor of 2.81. On the other hand, the odds of intention to use the pantry decrease by a factor of 0.92 for every unit increase in the Self-Stigma of Seeking Help Score.

Discussion

While understanding the reported use of food pantries is necessary and important to gauge reach and maintenance of the resource, factors influencing intention to use are understudied (Idehai et al., 2024). Therefore, our study is unique, as it analyzed the subset of individuals from the original study that were categorized as food insecure by the USDA adult food insecurity screener and that self-identified as never utilizing a campus food pantry (Duong et al., 2024). From the original study, which surveyed food pantry users and non-users, 35.7% of the overall participants were food insecure and did not utilize the on-campus food pantries (Duong et al., 2024). Our findings align with previous research that identified that 20–38% of food insecure college students do not utilize food pantries, and that usage is decreasing (El Zein et al., 2022; McArthur et al., 2020). Furthermore, our study enhances understanding of intention to use

Table 2. Descriptive Statistics of Dependent and Independent Variables

Variable	*N*	Mean (S.D.)	Minimum	Maximum
Dependent variable				
Intention	191	1.71 (0.83)	1	3
Independent variables				
Attitudes Score	177	29.86 (5.28)	7	42
Normative Belief Score	191	11.93 (2.18)	2	14
Perceived Behavioral Control Score	192	11.43 (2.37)	4	14
Food Pantry Self-Stigma Score	192	17.79 (3.43)	10	33
Self-Stigma of Seeking Help Score (SSOSH)	177	25.89 (9.30)	10	50

on-campus food pantries by utilizing the theory of planned behavior and previously validated self-stigma measures on food pantry use and seeking help. This provides specific insights into an at-risk population and the impacts of stigma, normative beliefs, and perceived behavioral control on intention to use an implemented resource like food pantries.

In a systematic review, researchers summarized barriers to food pantry use and highlighted findings similar to our current study (Idehai et al., 2024). For example, research conducted at a rural Appalachian university emphasized that food insecure students did not use the food pantry because of feeling embarrassed to do so and perceived insufficient need (McArthur et al., 2020). Additional studies described awareness of resources, food pantry staff and social support, and positive and accurate messaging as facilitators for food pantry use (Brito-Silva et al., 2022; El Zein et al., 2022; Esaryk et al., 2021). In our study, as perceived behavioral control scores increase, the probability that the respondent is in the highest category of intention (strong intention) to use on-campus food pantries increased. Perceived behavioral control reflects not only knowledge of available resources but also confidence in their ability to access those resources, their perceptions of ease of use, and their beliefs about whether structural and social conditions support or hinder use. Thus, increasing intention to use food pantries may require more than disseminating information alone; it also requires reducing logistical, psychological, and social barriers that affect students' sense of control over utilizing these services.

For instance, a recent study found that usage most significantly increased when food pantry information was shared by food pantry staff, as staff are more likely to provide accurate and comprehensive information to students, which can increase knowledge and confidence among students (Esaryk et al., 2021). Additionally, some staff are also student workers, which may help to reduce social barriers and stigma, and possibly increase acceptance (Esaryk et al., 2021). This suggests that informed individuals who are similar to food pantry users are important in effectively sharing information about food pantries, and possibly can assist in increasing perceived behavioral control and intention to use. Similarly, faculty can play a critical role in normalizing the use of food assistance resources by prominently displaying information about campus food pantries on Learning Management Systems (LMS) and including resource infor-

Table 3. Ordinal Regression Results

Predictors/ Thresholds	Odds ratio	Robust Standard Error	*p* value	95% Confidence Interval (Lower and Upper Bounds)	
Attitudes Score	0.92	0.05	0.17	0.82	1.03
Normative Belief Score	1.33	0.16	0.02	1.05	1.70
Perceived Behavioral Control Score	2.81	0.66	0.00	1.77	4.46
Self-Stigma Score	1.02	0.06	0.75	0.90	1.15
Self-Stigma of Seeking Help Score	0.92	0.02	0.00	0.88	0.97
Gender	1.32	0.50	0.45	0.64	2.76
Employment	0.64	0.24	0.23	0.31	1.32
Race	0.97	0.17	0.85	0.68	1.38
Year in School	1.33	0.29	0.18	0.87	2.03
Meal Plan	0.98	0.85	0.98	0.18	5.36
Campus Living	0.33	0.25	0.15	0.07	1.47
Thresholds					
/cut1	10.06	3.87		2.47	17.65
/cut2	12.17	4.00		4.32	20.01

mation in course syllabi. Research indicates that integrating basic needs support into classroom materials can increase students' awareness and reduce stigma associated with help-seeking behavior (Crutchfield & Maguire, 2018). Furthermore, incorporating food pantry tours and discussions during student orientation has been found to foster a welcoming and approving social environment and to encourage early use of resources (Goldrick-Rab et al., 2018). Our findings suggest that when participants had high social support and approval from people who were important to them or who were like them (this describes a high normative belief score), the probability of intention to use food pantries increased, which aligns with previous studies (Crutchfield & Maguire, 2018; Esaryk et al., 2021; Goldrick-Rab et al., 2018). These findings support the importance of continued social support for the utilization of campus resources. This aligns with suggestions from existing research on normalization of using pantries through changing location or the means by which individuals access pantry resources, and through dissemination of information and providing more available resources at pantries (Duong et al., 2024; Esaryk et al., 2021; Idehai et al., 2024).

Along with the benefits of increasing perceived behavioral control and changing normative beliefs, addressing stigma seems to be of the utmost importance. From our findings, as self-stigma for seeking help increased, the odds of intention to use food pantries decreased. This is consistent with the literature, as the systematic review concluded that stigma was the most frequently mentioned barrier to using and accessing a food pantry (Idehai et al., 2024). Research shows that public stigma (societal perceptions and attitudes about behavior or person) can contribute to the experience of self-stigma and impact the willingness to seek help (Latalova et al., 2014). Many factors in self-stigma that food pantry users identify overlap with non-users' reasons as well, confirming that self-stigma and public stigma have a relationship (Duong et al., 2024). Likewise, Brito-Silva et al. (2022) describe food pantry nonusers' feelings of not deserving or needing the pantry, which can be framed within the "why try" phenomenon (Corrigan et al., 2009), food pantry nonuser feelings of not deserving or needing the pantry, which is frequently reported in the literature (Brito-Silva et al., 2022; Corrigan & Matthews, 2003; Duong et al., 2024; El Zein et al., 2018, 2022; McArthur et al., 2020; Vogel et al., 2006).

A major concern is the impact that self-stigma has on consistently accessing resources. Fortunately, empowerment as a positive tool has been used in counseling and therapy in combating the possible negative effects of self-stigma and seeking help, including increased self-esteem, self-efficacy, social support, satisfaction, and quality of life (Corrigan et al., 2009; Latalova et al., 2014; Nelson et al., 2001). While empowerment has many definitions, it basically describes power (perceived and actual), locating and providing support, and acknowledging valued resources and how to access them. To put it simply, it is a strategy that can be taught to support opportunities for and conditions that promote choice and control. Empowerment can be a mediator between self-stigma and behavioral change (Corrigan et al., 2009; Latalova et al., 2014; Nelson et al., 2001). However, this has yet to be applied in nutrition and food systems work; specifically as a strategy for reducing self-stigma among food pantry nonusers. Additional research could investigate how implementing free empowerment counseling at a food pantry could encourage continued participation, and how offering empowerment counseling to current and incoming students increases usage of resources.

Limitations

While this study contributes to the field, it is not without limitations. This study was only conducted among a randomized cross-sectional sample of participants from a rural Appalachian university. Therefore, while important, it cannot be generalized to all university student experiences. Additionally, in this study we are only estimating associations and not causality. When assessing the data, our number of survey respondents dwindled to 137 responses we could use due to participants not completing the surveys and being dropped from the analysis sample. This reduced sample size may have limited statistical power and the ability to detect smaller associations. Furthermore, participation in the study was voluntary, introducing poten-

tial for self-selection bias. Students with greater interest in food insecurity issues or with personal experiences related to food access may have been more likely to participate, potentially influencing the observed associations. Although recruitment was anonymous, students may not have participated due to the fear of social stigma or a perceived lack of need. Finally, all measures were based on self-reported data, which are subject to recall bias and social desirability bias. Participants may have underreported or overreported food insecurity experiences or intentions to use campus food pantries. Despite these limitations, the study provides valuable insight into factors associated with intentions to use campus food pantries and highlights important considerations for future research.

Conclusions and Key Recommendations for Research

Our study provides specific insights into an at-risk population and the impacts of stigma, normative beliefs, and perceived behavioral control on intention to use food pantries at a rural, Appalachian campus. Our findings suggest possible implementation improvements to university resources, such as increasing locations and availability of campus food pantries, improving information dissemination about the food pantries, and providing more resources to empower food pantry users and non-users. For example, empowerment counseling could be a beneficial addition to food pantries to encourage recurring usage. Inclusion of food pantry information in course materials, such as syllabi, and discussion regarding resources available through the university can also increase the normalization of accessing help.

Some areas for continued research include examining the communication regarding food pantry services and assessing if this influences food pantry use; for example, exploring who provided information to users that ultimately led them to seeking and accessing resources and why. This would provide more information about possible information champions. More studies should be conducted to compare university food pantries to examine implementation and student experience to better generalize practical implications. The effect of empowerment counseling as an addition to the food pantry could also be examined to determine if it would influence stigma and intention to use food pantry resources and help-seeking behaviors. Although we theorized that all these pieces would have an impact on the stigmatization of accessing help, these are large areas of research that require attention and which could be studied utilizing a multi-university design and Implementation Science theories, models, and frameworks to compare factors in using campus resources as well as the stigmatization of accessing resources.

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Estimates of food insecurity among Cooperative Extension employees at a southeastern land-grant university

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Abstract

Food insecurity among public health professionals is an underexplored issue with implications for workforce well-being and program delivery. Although Cooperative Extension (CE), the applied outreach arm of land-grant universities, plays a critical role in advancing food systems and community health, little is yet known about the food security status of CE employees themselves. This study examined the prevalence and predictors of food insecurity among CE employees at a southeastern land-grant university using data from a 2024 cross-sectional survey (N = 95; 12% response rate). Food security was assessed using the USDA Household Food Security Module. Logistic regression models were used to evaluate the associations between food insecurity and sociodemographic, work-related, and financial resilience (absorptive capacity) variables. Over one in five respondents (22.1%) reported experiencing food insecurity. Higher absorptive capacity (AOR = 0.02, 95% CI: 0.0006-0.16) and educational attainment (AOR = 0.44, 95% CI: 0.17-0.92) were significantly associated with lower odds of food insecurity, while income and job classification were not. Food insecurity was significantly linked to self-reported poor

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physical and mental health ($p < 0.05$), and 23% of respondents reported using at least one nutrition assistance program. These findings revealed that economic vulnerability exists within a key public health workforce, and underscore the need for institutional policies that support employee financial resilience and food access. By addressing food insecurity among CE employees, both workforce wellness and the effectiveness of community-based programming may be enhanced.

Keywords
food insecurity, nutrition security, Cooperative Extension, land-grant university, public health workforce, absorptive capacity, employee wellness, workforce vulnerability

Introduction

Food insecurity, defined by the U.S. Department of Agriculture (USDA) as the lack of consistent access to enough food for an "active, healthy life" (USDA Economic Research Service [USDA ERS], 2026), continues to be a significant public health issue in the U.S. (Anderson, 1990). In 2023, about 18 million (13.5%) of the U.S. population experienced food insecurity (Rabbitt et al., 2024). Food insecurity is associated with numerous adverse physical and mental health outcomes, including increased risk of chronic diseases, lower overall health, impaired childhood development, higher rates of depression and anxiety, and diminished economic productivity (Gundersen & Ziliak, 2015; Gundersen et al., 2011; Jones, 2017; Martin et al., 2016; Seligman et al., 2010). Recently, the concept of nutrition security, the "consistent access, availability, and affordability of foods and beverages that promote well-being, prevent disease, and if needed, treat disease" (Mozaffarian et al., 2021, p. 1605), has gained prominence in the U.S. Nutrition security builds on food security, emphasizing the coexistence of food insecurity and diet-related diseases.

Nutrition security and food access are a strong emphasis of the work of Cooperative Extension (CE), the applied outreach arm of land-grant universities. The Morrill Acts of 1862 and 1890 established the U.S. system of land-grant universities, institutions to "democratize" higher education and address societal needs via research, teaching, and community engagement (Association of Public & Land-Grant Universities [APLU], 2025). CE delivers science-based education and locally relevant programs on topics spanning agriculture, food production, community development, disaster assistance, digital and technology literacy, 4-H youth development, and food access and health promotion that advance public health and well-being. These initiatives are accomplished through a coordinated network and partnership between on-campus administrators, disciplinary faculty ("specialists"), county-based educators ("extension agents," typically classified as administrative/professional faculty), and support staff who provide administrative and programming support.

CE's national framework designates food security as a key social determinant of health and well-being (Burton et al., 2021). Research, educational programs, and partnerships with schools, farms, and community organizations allow CE personnel to implement youth gardening, farm-to-school initiatives, nutrition education classes, and health promotion campaigns that contribute to food and nutrition security (Burton et al., 2021; Cuite & Errickson, 2022; Lin et al., 2024; Olayemi et al., 2025; Schonberger et al., 2022; Sowerwine et al., 2019)). The 2024 National Cooperative Extension's Health and Well-Being Infrastructure Survey indicated that about 4,200 CE employees were dedicated to delivering health and well-being programming, for their communities and across responding institutions, with food security identified as an inte-

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gral component of this work (Center for Community Health and Evaluation, 2024).

Despite these contributions, the food security status of CE employees themselves has not been previously explored and it is not clear how food security presents itself within CE.
This represents a significant knowledge gap given the broader evidence that employment does not necessarily confer protection against food insecurity. Nationally, more than half of households experiencing food insecurity include at least one working adult (Rabbitt et al., 2024).
If those tasked with promoting food security are themselves at risk, the resulting stresses may undermine their personal well-being, ultimately manifesting as poorer mental and physical health (Martin et al., 2016). These stresses may also undermine the effectiveness of their outreach initiatives (Jones, 2017; Liebe et al., 2024). Furthermore, household financial resilience (absorptive capacity) has emerged in the literature as a critical predictor of food security, independent of income level (Ansah et al., 2019; Calloway et al., 2022; Calloway et al., n.d.; d'Errico et al., 2018; Smith & Frankenberger, 2018). Absorptive capacity is a household's ability to withstand short-term financial shocks such as unexpected expenses or job loss using quickly accessible resources. Understanding its contribution alongside traditional demographic and employment factors could provide insights into potential intervention targets for workforce stability.

The purpose of this study was to examine the prevalence of food insecurity among CE employees at a southeastern land-grant university founded in 1872 and to identify sociodemographic and work-related factors associated with food insecurity, including income, household financial resilience/absorptive capacity, job classification, and work location. Given the role that CE plays in promoting food systems, food access, and food security, understanding employee's personal experiences with food security is important for informing organizational practices and policy.

Literature Review

National data show that employment does not fully protect households from food insecurity: more than half of food-insecure households include at least one working adult (Rabbitt et al., 2024). Household financial resilience, often conceptualized as absorptive capacity, has emerged as a critical predictor of food security beyond income alone. Absorptive capacity reflects a household's ability to manage short-term financial shocks through liquid assets, manageable expense burdens, and stable housing (Calloway et al., 2022). Prior research indicates that households with higher absorptive capacity are less likely to experience food insecurity, even at similar income levels, suggesting that resilience to income volatility and unexpected costs can be as important as income in determining food security status (Ansah et al., 2019; Calloway et al., 2022; d'Errico et al., 2018; Smith & Frankenberger, 2018).

Educational attainment has also been associated with lower risk of food insecurity. Higher levels of education may increase earning potential, but they may also improve awareness of available resources, strengthen problem-solving skills, and facilitate network-building, all of which can buffer against economic shocks and food hardship (Gundersen & Ziliak, 2015; Smith & Frankenberger, 2018). Together, financial resilience and education may shape households' ability to navigate economic constraints and maintain food security.

Research on specific occupational groups has documented substantial variability, however, in food insecurity prevalence. For example, 27% of employees at an urban worksite experienced food insecurity (Feuerstein-Simon et al., 2019), while studies of early care and education workers found prevalence ranging from 21% to 41% (Loh et al., 2020; Swindle et al., 2018; Swindle et al., 2021). By contrast, studies among healthcare workers have reported lower rates, in the range of 6–7% (Srinivasan et al., 2021). These findings highlight that food insecurity can affect a wide range of essential workers, including those in health and education sectors. In higher education, an emerging body of research has examined food insecurity among students, with comparatively fewer studies focused on university staff and faculty. However, available evidence suggests that university employees can also experience food insecurity, with reported prevalence in some staff cohorts compa-

rable to or exceeding national averages (Coca et al., 2020; Dreier et al., 2016; Kent et al., 2022; Riddle et al., 2020). These studies underscore that universities are not immune to workforce food insecurity, even when they host food and nutrition programs and services aimed at students and community members.

Despite the robust literature on food insecurity among various workforces and the growing emphasis on nutrition security and financial resilience, little is known about how these dynamics operate within land-grant universities themselves, particularly in CE workforces whose mission centers on advancing food and nutrition security in communities. This study addresses that gap by examining food insecurity, financial resilience, and associated factors within CE employees at one land-grant university.

Methods

This analysis draws on data from a 2024 cross-sectional survey of food access and well-being among employees at a southeastern land-grant university to explore specific research questions related to food security, health, and financial resilience within the university's CE workforce.

Respondents

Approximately 800 CE employees at the university (including county-based extension agents, campus-based specialists, and CE support staff) were eligible for this study. The study was approved by the Institutional Review Board (IRB: 24-067). Recruitment efforts primarily targeted non–tenure-track university employees through relevant employee listservs and flyers to maximize participation. Although tenure-track faculty were eligible for this secondary analysis, the recruitment strategy limited their representation in the study, resulting in only a small number of tenure-track respondents. The survey was administered online using Qualtrics. Eligible respondents were staff and faculty members within CE aged 18 and older (tenure track faculty, non-tenure track faculty, classified and university staff). Student employees and individuals who did not meet these criteria were excluded from the study. Data collection occurred between February and May 2024. All responses were anonymized and securely stored in accordance with IRB requirements.

Measures

Sociodemographic Information. Respondents provided information on age, sex, race, ethnicity, number of children in the household, household income, participation in nutrition assistance programs, college of employment, job classification, educational attainment, and job location. Variables were collected as categorical or continuous, as appropriate; for example, age and income were collected as continuous variables, while sex and job classification were collected as categorical variables.

Food Security. Food security status was measured using the USDA Household Food Security Survey Module (Bickel et al., 2000). Households with children completed the 18-item version, and those without children completed the 10-item adult version. Each item was coded as affirmative (1) or negative (0). For households with children, scores ranged from 0 to 18, categorized as high food security (0), marginal food security (1–2), low food security (3–7), and very low food security (8–18). For households without children, scores ranged from 0 to 10, with categories of high (0), marginal (1–2), low (3–5), and very low food security (6–10). The recall period was the past 12 months (Bickel et al., 2000; USDA ERS, 2012). Missing or ambiguous responses were treated as missing data and excluded from scoring.

Physical and Mental Health. Physical and mental health were each assessed using a single-item question: "How would you rate your overall physical health?" and "How would you rate your overall mental health?" Responses were recorded on a 5-point Likert scale from 1 (terrible) to 5 (excellent). No specific timeframe was indicated. These single-item measures were chosen to minimize respondent burden and have been used as proxies for more comprehensive scales in prior research, although their limitations are acknowledged (Allen et al., 2022).

Absorptive Capacity. Household financial resilience (absorptive capacity) was measured using a vali-

dated 9-item Household Financial Resilience Scale (Calloway et al., 2022). This tool assesses short-term coping capacity for financial shocks, such as income disruption or unplanned expenses, based on liquid assets, expense burden, and housing stability. Final scores ranged 0–3, with higher values indicating greater financial resilience.

Data Analysis

Descriptive statistics (means, standard deviation, frequencies, and percentages) were used to summarize the demographic characteristics and work-related factors generated by respondents. Association between food insecurity and mental/physical health were tested with Fisher's exact test, and logistic regression analyses examined the relationship between sociodemographic and work-related factors and food security status in two models. Model 1 focused on demographic characteristics and absorptive capacity, and Model 2 included additional work-related factors. For the logistic regression, part-time faculty ($n = 3$) and tenure-track faculty ($n = 3$) were excluded because extremely small subgroup sizes can produce unstable coefficient estimates and compromise model reliability (Peduzzi et al., 1996). The two-model rationale was to isolate sociodemographic versus occupational effects. All analyses were performed using R version 4.4.1 (R Core Team, Vienna, Austria), and models were fit using the GLM package (Touchon, 2021). Statistical significance was set a priori at $p < 0.05$.

Results

A total of 95 respondents met the inclusion criteria for this analysis for a response rate of approximately 12%. Over three-quarters (86.3%) were female. The mean age was 42.1 years (SD ± 11.6). The average number of years that respondents had worked at the university was 10.3 years (SD ± 9.8). Of the respondents, 42 (44.2%) were administrative and professional faculty and about half ($n = 47$, 49.5%) held a postgraduate degree. Notably, 22 (23.2%) of the total respondents participated in at least one nutrition assistance program. Additional sociodemographic characteristics are summarized in Table 1.

Table 1. Sociodemographic and Employment Characteristics of Cooperative Extension Employees at a Southeastern Land-Grant University ($N = 95$)

Characteristics	*n* (%) or mean ± SD
Age (years)	42.1 ± 11.6
Years at Institution	10.3 ± 9.8
Absorptive Capacity	2.0 ± 0.6
Household Size	2.4 ± 1.0
Employee respondent type	
Administrative/Professional (AP) Faculty	42 (44.2)
Teaching and Research Faculty	14 (14.7)
Part-Time Faculty	3 (3.2)
Classified Staff	12 (12.6)
University Staff	21 (22.1)
Tenure-Track Faculty	3 (3.2)
Race	
Black or African American	10 (10.5)
White	82 (86.3)
Other race [a]	3 (3.2)
Ethnicity	
Hispanic	3 (3.2)
Non-Hispanic	89 (93.7)
Not sure	3 (3.2)
Sex	
Male	13 (13.7)
Female	82 (86.3)
Education Attainment	
High school or GED or less than a high school diploma	14 (14.7)
Some college	7 (7.4)
Associate	9 (9.5)
Bachelor	18 (18.9)
Postgraduate	47 (49.5)
Marital Status	
Married	56 (58.9)
Divorced /Separated/Widowed	13 (13.7)
Never Married	26 (27.4)
Job Status/Location	
On-campus	15 (15.8)
Off-campus, not at home	67 (70.5)
Off-campus, at home	3 (3.2)
Hybrid	10 (10.5)
Number of Children in the Household	
0	65 (68.4)
1	16 (16.8)
2	11 (11.6)
3+	3 (3.2)

continued

continued

Assistance Program Participation (select all that apply)	
One or more programs[2]	36 (32.9)
None	73 (67.0)
Persons Living in the Household (select all that apply)	
Live alone	16 (12.6)
Child/children under 5 years old	12 (9.5)
Child/Children 5 years or older	29 (22.8)
Spouse	53 (41.7)
Unmarried Partner	12 (9.5)
Parent or Grandparent	4 (3.2)
Other	1 (0.8)
Monthly Household Income ($)	
<2,000	8 (8.4)
2,000–4,000	28 (29.5)
4,000 –6,000	20 (21.0)
6,001–8,000	18 (18.9)
>8,001	21 (22.1)

[a] American Indian or Alaska Native; Asian. [2]Child Health Insurance Program; National School Lunch Program/School Breakfast Program; Supplemental Nutrition Assistance Program; Supplemental Nutrition Assistance Program Education/ Expanded Food and Nutrition Education Program; Temporary Assistance for Needy Families; Food banks; Head Start; Medicaid; Public Housing; Unemployment Insurance

Food Security Status

Based on the USDA Household Food Security Survey Model, 22.1% (n = 21) of respondents experienced food insecurity in the past year. Specifically, 54.7% (n = 52) reported high food security, 23.2% (n = 22) marginal, 9.5% (n = 9) low, and 12.6% (n = 12) very low food security.

Food insecurity was more prevalent among respondents reporting poor mental and physical health. Among those rating their mental health as "poor," 66.7% experienced food insecurity, compared to 16.7% among those rating their mental health as "excellent." Similar trends were observed for physical health (Figure 1). There was a significant association between reported food security status and self-rated mental health ($p < 0.05$) and self-rated physical health ($p < 0.05$). Specifically, respondents experiencing food insecurity were more likely to report poorer mental and physical health (poor or terrible) compared to food secure respondents, who more frequently reported excellent to average mental and physical health.

Table 2 summarizes the logistic regression tests. In the first model, which controlled for soci-

Figure 1. Food Insecurity by Self-Reported Health Among Cooperative Extension Employees at a Southeastern Land-grant University

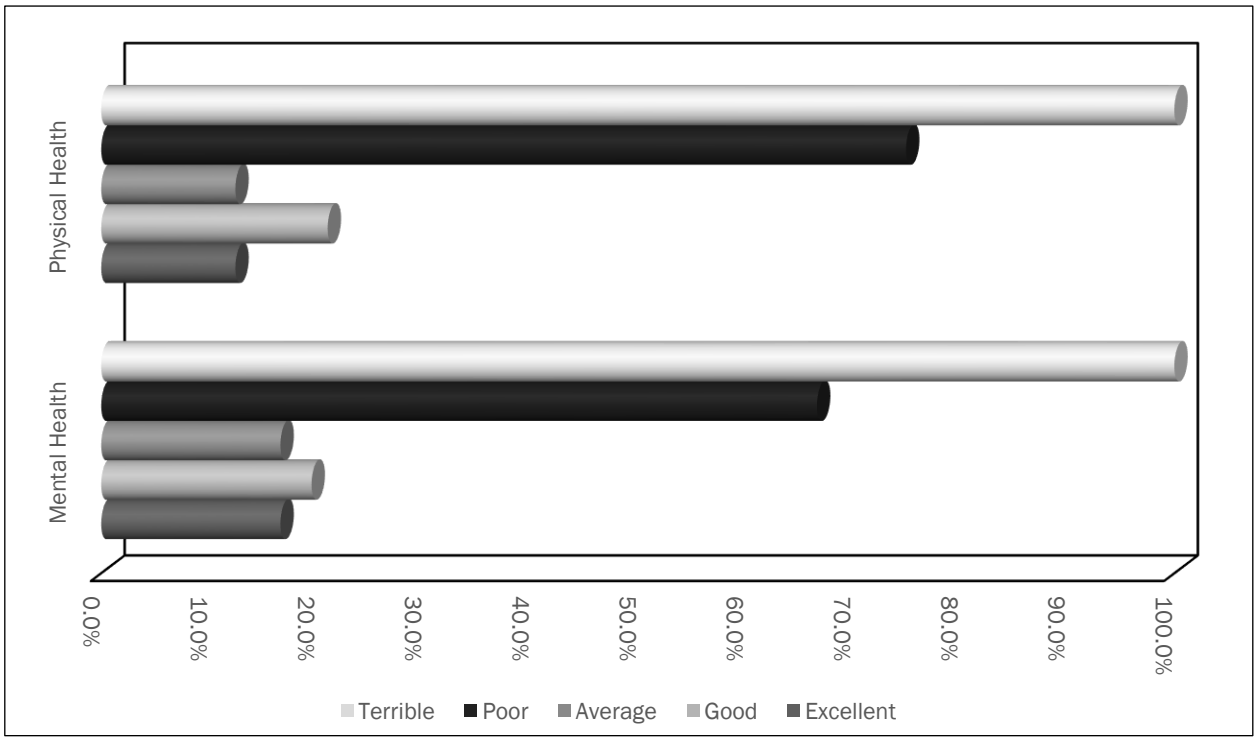

Table 2. Logistic Regression Models: Predictors of Food Insecurity Among Cooperative Extension Employees at a Southeastern Land-Grant University

Predictor	Model 1 AOR (95% CI)	*p*-value	Model 2 AOR (95% CI)	*p*-value
Age (in years)	0.97 (0.90-1.03)	0.32	1.04 (0.94-1.16)	0.48
Race	0.88 (0.39-2.19)	0.76	0.85 (0.30-2.86)	0.77
Ethnicity	3.31 (0.32-89.5)	0.38	20.70 (0.41-11900)	0.21
Highest Grade Completed	0.61 (0.35-1.02)	0.07	**0.44 (0.17-0.92)**	**<0.05**
Sex	0.52 (0.07-3.96)	0.51	0.81 (0.05-12.6)	0.87
Children in the Household	0.72 (0.11-5.30)	0.73	0.35 (0.03-3.32)	0.34
Marital Status	1.37 (0.48-4.30)	0.56	2.12 (0.66-8.27)	0.23
Absorptive Capacity	**0.04 (0.004-0.22)**	**<0.01**	**0.02 (0.0006-0.16)**	**<0.01**
Income: $2,000–$4,000	0.24 (0.01-3.38)	0.32	0.17 (0.003-2.89)	0.27
Income: $4,001–$6,000	0.52 (0.02-7.96)	0.65	1.02 (0.03-23.50)	0.99
Income: $6,001–$8,000	0.06 (0.001-1.85)	0.15	0.07 (0.0001-7.44)	0.31
Income: >$8,001	0.86 (0.04-17.1)	0.92	1.32 (0.02-54.90)	0.88
Does Not Participate in Any Assistance Program	0.67 (0.12-3.90)	0.64	1.85 (0.18-30.10)	0.62
Job Location (on campus, off campus at home, off campus not home, hybrid)	—	—	0.76 (0.13-3.62)	0.75
Years at institution	—	—	0.87 (0.71-1.02)	0.11
Job Classification	—	—	0.66 (0.31-1.24)	0.22

AOR = Adjusted Odds Ratio. CI = Confidence Interval; $P < 0.05$ is considered statistically significant.

odemographic factors, higher absorptive capacity was significantly associated with lower odds of food insecurity (AOR = 0.04, 95% CI: 0.004-0.22, $p < 0.01$).).In the second model, which controlled for both sociodemographic and work-related factors, higher absorptive capacity (AOR = 0.02, 95% CI: 0.0006-0.16, $p < 0.01$) and higher education attainment (AOR = 0.44, 95% CI: 0.17-0.92, $p < 0.05$) were significantly associated with reduced odds of food insecurity. Income was not a significant predictor after adjustment, nor were job classification or work location.

Discussion

This study provides one of the first assessments of food insecurity among CE employees at major U.S. land-grant universities, and revealed that more than one in five (22.1%) CE employees surveyed experienced food insecurity. Although this prevalence exceeds national averages (Rabbitt et al., 2024), it should be interpreted as reflecting conditions within a single institution rather than the CE workforce as a whole. Nonetheless, the findings parallel trends in other university staff cohorts (Coca et al., 2020; Dreier et al., 2016; Kent et al., 2022; Riddle et al., 2020). This is especially notable considering that 23.2% of the respondents reported using at least one form of nutrition assistance program. The high prevalence among CE employees underscores that individuals employed by an organization whose aim is to support agriculture, food production, food access, and health nevertheless are also vulnerable to food insecurity and household financial shocks.

The adjusted regression analysis revealed both higher absorptive capacity (financial resilience) and educational attainment as protective for food security. The significance of household financial resili-

ence is consistent with the literature, as respondents with higher absorptive capacity have greater ability to meet financial shocks and household expenses, which leads to consistently and significantly lower odds of experiencing food insecurity (Calloway et al., 2022). This finding aligns with broader research showing that, even among working adults, financial and household resilience may contribute to greater household food security by mitigating the effects of income volatility on food security status (Ansah et al., 2019; Calloway et al., 2022; d'Errico et al., 2018; Liebe et al., 2023; Smith & Frankenberger, 2018).

The protective effect associated with educational attainment suggests that, beyond income, education may support food security through increased access to information, resource navigation skills, and professional networks (Gundersen & Ziliak, 2015; Smith & Frankenberger, 2018). That income was not statistically significant after adjustment may reflect both the relatively narrow income range in this sample and interaction effects.

Work-related variables and sociodemographic factors (work location, years of employment, sex, marital status, and race/ethnicity) were not statistically significant predictors in the fully adjusted model, apart from absorptive capacity and educational attainment. Job classification was also found not to be significantly associated with food security. It is important to note that almost a quarter of administrative and professional faculty, who would include county-level extension agents, and 33.3% of classified staff and 23.8% of university staff, reported being food insecure (Appendix, Table A1). These findings suggest that financial vulnerability may cut across professional boundaries among CE employees, emphasizing the need for broad interventions rather than focusing interventions only on specific job types or demographic groups. Additional sociodemographic patterns related to food security are detailed in Appendix Tables A2–A5.

Notably, food insecurity was strongly associated with both poor physical and mental health status. Respondents rating their physical or mental health as "poor" or "terrible" were substantially more likely to experience food insecurity, reflecting the established literature which documents bidirectional relationships between food security and health outcomes (Gundersen & Ziliak, 2015; Gundersen et al., 2011; Maynard et al., 2018). This relationship indicates that supporting food security among employees may yield downstream benefits in workforce wellness and productivity.

Although participation in nutrition assistance program was relatively low in this sample, the prevalence of food insecurity was substantial. This pattern is consistent with prior work demonstrating elevated rates of food insecurity among populations whose incomes are above program thresholds or whose circumstances make them functionally ineligible for assistance, even when they experience material hardship (Furness et al., 2004; Keith-Jennings et al., 2019). Low assistance program participation among the respondents therefore does not necessarily indicate mild or transient food hardship; rather, it may reflect structural and categorical barriers to program access. Many vulnerable adults, particularly those without dependent children, are subject to strict time limits and may receive only three months of SNAP benefits in a 36-month period, even when their financial situation remains precarious (Keith-Jennings et al., 2019). This suggests that the underutilization of nutrition assistance program in this sample may be at least partly structurally driven, rather than evidence of limited need.

This study is not without limitations, including that it is a cross-sectional study, which discourages causal inference. The sample is from a single university system, limiting generalizability, though the pattern aligns with emerging data from other higher education settings cohorts (Coca et al., 2020; Dreier et al., 2016; Kent et al., 2022; Riddle et al., 2020). The reliance on self-reported metrics may also introduce reporting bias. Selection bias is another limitation that might have affected the estimates from this study, as potential respondents who were experiencing food insecurity may have been either more or less likely to participate. Also, the recruitment strategy of the original research limited the number of eligible tenure-track positions included in this current study; this low representation may also explain the higher prevalence of food insecurity observed in our sample, as tenure-track positions tend to have higher salaries com-

pared to non-tenure-track faculty and staff. Several contextual factors may help explain the elevated prevalence observed in this sample, such as regional cost-of-living and salary structures that differ across job classifications among others. These considerations suggest caution in extrapolating the findings to the broader CE workforce. Despite these limitations, the results offer robust, actionable insights given the use of validated measures.

Conclusions

This study reveals a high prevalence of food insecurity among CE employees at a southeastern land-grant university, exceeding both national averages and estimates among other U.S. university personnel. The pivotal role of household absorptive capacity highlights financial resilience as the linchpin of food security among working adults, including those in educational and outreach settings. These findings highlight that the professionals tasked with promoting food security and nutrition security in communities may themselves actually experience economic vulnerability, an issue with implications for both employee health and program effectiveness.

Future research should build upon these preliminary findings using longitudinal and mixed method designs to examine how changes in income, benefits, and absorptive capacity influence financial resilience and food security trajectories over time. A multi-year cohort study across several land-grant universities could help identify systemic and regional factors affecting workforce food security. Complementary qualitative inquiry, such as focus groups and interviews, could deepen understanding of employees lived experiences, coping mechanisms, and perceptions of organizational support in order to guide institutional responses. In parallel, implementation studies are also needed that would test workplace-based interventions, such as emergency food pantries, financial literacy and budgeting programs, institutional hardship funds, and annual employee cost-of-living salary adjustments to determine their effectiveness in improving food security outcomes. By embedding such efforts into institutional wellness and human resource strategies, CE systems can better align their internal practices with their external commitments to equity and community health

CE systems and university administrators can act on these findings by embedding workforce food security efforts into institutional wellness and human resources initiatives. This could include formalizing a workforce food security policy that defines the institution's commitment to employee well-being, establishing internal hardship funds or grocery-subsidy programs, and forging partnerships with the community to expand staff resources. Practical models from higher-education settings are already emerging: a few universities have launched employee-focused pantries to directly address staff and faculty food access challenges (Haughey, 2024; University of Washington, 2026). By adapting and evaluating such interventions, CE systems can model holistic, equity-driven approaches to food security, not only for the communities but for the employees.

Addressing food insecurity among CE employees is not merely a matter of employee support; it is vital to the integrity and sustainability of CE and the land-grant university mission. Empowering the workforce with greater financial resilience and food access strengthens the foundation of Extension outreach and public health practice. As institutions navigate evolving socioeconomic contexts and workforce needs, integrating employee food security into broader wellness and operational strategies can help ensure that those who lead food security and community health initiatives are themselves supported and thriving.

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Appendix

Supplementary Analyses

Food security status varied by job classification, college/unit, race, sex, marital status, job status/location, and educational attainment. For example, food insecurity was more prevalent among classified staff and those with lower educational attainment. Tables A1–A5 provide detailed breakdowns by these characteristics.

Table A1. Food Security by Job Classification Among Cooperative Extension Employees at a Southeastern Land-Grant University

Job Classification	*n*	Food Secure (%)	Food Insecure (%)
Administrative and Professional (AP) Faculty	42	78.6	21.4
Teaching and Research Faculty	14	85.7	14.3
Part-Time Faculty	3	66.7	33.3
Classified Staff	12	66.7	33.3
University Staff	21	76.2	23.8
Tenure-Track Faculty	3	100.0	—

Table A2. Food Security by Race and Marital Status Among Cooperative Extension Employees at a Southeastern Land-Grant University

	n	High Food Security (%)	Marginal Food Security (%)	Low Food Security (%)	Very Low Food Security (%)
Race					
Black or African American	10	30.0	20.0	10.0	40.0
White	82	58.5	22.0	9.8	9.8
Others [a]	3	33.3	66.7	-	-
Marital Status					
Married	56	66.1	17.9	5.4	10.7
Divorced/Separated/Widowed	13	53.8	15.4	23.1	7.7
Never Married	26	30.8	38.5	11.5	19.2

[a] American Indian or Alaska Native; Asian.

Table A3. Food security by Sex Among Cooperative Extension Employees at a Southeastern Land-Grant University

Sex	*n*	High Food security (%)	Marginal Food Security (%)	Low Food Security (%)	Very Low Food Security (%)
Male	13	53.8	15.4	15.4	15.4
Female	82	54.9	24.4	8.5	12.2

Table A4. Food Security by Job Status and Educational Attainment Among Cooperative Extension Employees at a Southeastern Land-Grant University

	n	High Food security (%)	Marginal Food Security (%)	Low Food Security (%)	Very Low Food Security (%)
Job Status					
On-campus	15	60.0	26.7	-	13.3
Off-campus, not at home	67	50.7	22.4	11.9	14.9
Off-campus, at home	3	33.3	33.3	33.3	-
Hybrid	10	80.0	20.0	-	-
Educational Attainment					
High school or GED or less than a high school diploma	14	28.6	21.4	14.3	35.7
Some College	7	42.9	-	28.6	28.6
Associate	9	55.6	44.4	-	-
Bachelor	18	27.8	38.9	11.1	22.2
Postgraduate	47	74.5	17.0	6.4	2.1

Table A5. Concerns About Food Lasting Among Cooperative Extension Employees at a Southeastern Land-Grant University

	n	%
We worried whether our food would run out before we got money to buy more (*N* = 95)	25	26.3
The food that we bought just didn't last, and we didn't have money to get more (*N* = 93)	23	24.7
We couldn't afford to eat balanced meals (*N* = 95)	24	25.3
Did you ever cut the size of your meals or skip meals because there wasn't enough money for food? (*N* = 41)	16	39.0
Did you ever eat less than you felt you should because there was not enough money for food? (*N* = 73)	20	27.4
Were you ever hungry but didn't eat because there wasn't enough money for food? (*N* = 94)	9	9.6
Did you lose weight because there wasn't enough money for food? (*N* = 91)	6	6.6
Did you/other adults in your household ever not eat for a whole day because there wasn't enough money for food? (*N* = 24)	6	25.0

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Association between nutrition assistance programs and household produce waste during the COVID-19 pandemic

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Abstract

Fresh produce is the most wasted food, accounting for about 45% of household food waste in the United States. The literature is inconclusive about whether nutrition assistance programs aimed at increasing access to healthy food affect household food waste, particularly during the COVID-19 pandemic. To address this knowledge gap, we investigated the association between participation in nutrition assistance programs (food pantries and the Supplemental Nutrition Assistance Program, or SNAP) and changes in household produce waste since the beginning of the COVID-19 pandemic. Given that more fresh produce was distributed to

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food pantries during the pandemic, we examined whether the perceived quality of fresh produce at food pantries may influence household food waste behavior. We conducted an online survey for adults residing in the Capital Region of New York state from October to December 2021. Among 504 respondents, 27% reported throwing away less produce than usual since the COVID-19 pandemic began, 22% used food pantries, and about half perceived the quality of fresh produce at those pantries as poor. Approximately one-third of respondents were SNAP participants, including the Pandemic Electronic Benefit Transfer (P-EBT). We found that food pantry users who rated produce quality as acceptable had 2.4 times the odds of wasting less produce since the COVID-19 pandemic began compared to non-users of food pantries. Similarly, SNAP/P-EBT users were more likely to report less household produce waste compared to non-SNAP/P-EBT users. Our findings highlight that participation in food assistance programs may help reduce household food waste and underscore the importance of maintaining fresh produce quality at a level clients perceive as acceptable. We suggest greater collaboration among public health nutrition, food waste research, and food systems stakeholders to work toward the common goals of efficiently distributing healthy food, reducing food waste, and eliminating hunger.

Keywords
household food waste, fresh produce, fruit and vegetables, COVID-19, pandemic, food pantries, SNAP, perceived food quality, nutrition assistance program, New York State

Introduction

In the U.S., over one-third of the food produced is never eaten (U.S. Environmental Protection Agency [US EPA], 2023a). Food waste occurs at various stages of the food's life cycle. According to the US EPA, the largest share of food waste is generated by the food retail, food service, and residential sectors, with approximately 40% coming from individual households (2023b). The literature confirms that food wasted at the final consumption stage is the most significant source of food loss (Bellemare et al., 2017; Buzby et al., 2014; Yu & Jaenicke, 2020). Furthermore, fresh produce is the most wasted food in U.S. households. A ReFED (2025) study indicated that in 2024, fresh produce accounted for 45.2% of household food waste, three times the amount of the second-most-wasted food, dry goods (14.9%). A 2023 survey of 9,259 American consumers found that vegetables were the most-wasted food group, with an average of 1.3 cups wasted per week, closely followed by fruits, with 1.2 cups wasted per week (MITRE & Gallup, 2023).

For several decades, the U.S. public health community has focused on promoting fruit and vegetable consumption. Most Americans, particularly low-income and food-insecure individuals, are not meeting the recommended levels of fruit and vegetable intake, putting them at risk of various nu-

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trition-related diseases (2025 Dietary Guidelines Advisory Committee, 2024; Havas et al., 1994; Lee et al., 2022). High costs, limited access to grocery stores, and perceived constraints on convenience are major barriers to low-income individuals' regular consumption of fresh fruits and vegetables (Haynes-Maslow et al., 2015). Nutrition safety-net programs, such as the Supplemental Nutrition Assistance Program (SNAP) and food pantries, play an integral role in increasing access to fresh produce, promoting its consumption, and reducing hunger (Eicher-Miller, 2020; Engel & Ruder, 2020). However, little is known about how much food from nutrition assistance programs is wasted at home. Some studies demonstrate that low-income and food-insecure households waste less food (Daniel, 2016; Ghafoorifard et al., 2022; Yu & Jaenicke, 2020), while other studies report no associations between income level and food waste, suggesting that food waste behavior is complex and cannot be explained by a single factor (Schanes et al., 2018).

The COVID-19 pandemic introduced additional challenges for nutrition assistance programs. Due to disruptions in the food supply chain and employment, the number of food-insecure households increased significantly across the U.S. (Niles et al., 2021; Pryor & Dietz, 2022). To combat this phenomenon, SNAP expanded eligibility and benefits (Restrepo, 2023), and food pantries increased the collection of fresh produce through their own networks and special government programs (Huang et al., 2023; Larison et al., 2021; Winkler et al., 2023). As a result, more fresh produce was collected and distributed than usual (Huang et al., 2023; Larison et al., 2021). Studies reported that utilization of nutrition assistance programs was associated with increased fruit and vegetable consumption during the pandemic (Bertmann et al., 2021; Lee et al., 2023; Woo Baidal et al., 2024). However, researchers also note that the increased availability of fresh produce can lead to greater household food waste, particularly when the produce clients receive is of poor quality or otherwise undesirable (Kihlstrom et al., 2019; Pruden et al., 2020). Did participation in nutrition assistance programs affect household produce waste during the COVID-19 pandemic? To answer this question, we analyzed survey data collected in the last quarter of 2021 to investigate the association between participation in nutrition assistance programs and changes in household produce waste since the onset of the COVID-19 pandemic. We incorporated the perceived quality of fresh produce at food pantries in the analysis. Findings from this study can help public health professionals better understand the levers of household food waste and, in turn, safeguard fruit and vegetable consumption and reduce hunger during the pandemic.

Data Source

We used the COVID-19 Food Access Survey III (FAS3), which aimed to understand and track adults' experiences, attitudes, perceptions, and needs related to food security and access. We adapted the questionnaire developed by the National Food Access and COVID research Team (NFACT), a consortium that assessed COVID-related food access across multiple U.S. study sites (Niles et al., 2021). The study community was the Capital Region of New York state. This region is home to 1.24 million people living throughout 11 counties and includes the Albany-Schenectady-Troy Metropolitan Statistical Area. During the first 10 months of the COVID-19 pandemic, 40% of residents in this region reported experiencing food insecurity at some point (Feingold et al., 2021). We administered FAS3 via a Qualtrics online panel from October 20, 2021, to December 13, 2021, or approximately 19 to 21 months since the beginning of the COVID-19 outbreak. The eligibility criteria were adults aged 18 or older who lived in the study region and who were able to consent and take a self-administered survey in English or Spanish. Qualtrics sent the sociodemographic screener to potential participants to ensure half of the respondents were from low-income households (i.e., annual household income less than $50,000[1]). As an incentive, participants received "points" based on the length and complexity of the Qualtrics survey, which they could redeem for monetary rewards later.

[1] All currency in this article is in U.S. dollars.

Measures

The outcome of interest is whether less fresh produce was wasted at the household level since the beginning of the COVID-19 pandemic. The binary variable ("Yes" for wasted less fresh produce) was derived from the question "Has your household done any of the following in the past year?" and the response option "Throw away less fresh produce than normal." The exposure variables were self-reported household participation in the food pantry and in SNAP during the COVID-19 pandemic. To incorporate the perceived quality of the food pantry's produce into the food pantry variable, we examined how food pantry users had responded to the statement "the food pantry has good quality of fruits and vegetables" in the section on their experience of food pantry usage in the past year. Those who strongly disagreed or disagreed with this item were considered to have rated the quality of fresh produce as "poor," while those who strongly agreed, agreed, or had no opinion were considered to have rated it as "acceptable." We then created a three-category variable to indicate whether respondents were food pantry users who rated the quality of fresh produce as poor or acceptable, or were non-users of food pantries. The SNAP variable was binary; "Yes" indicated SNAP or Pandemic Electronic Benefit Transfer (P-EBT) enrollment.

Additionally, we measured changes in fruit and vegetable consumption and cooking behavior because the literature suggests these behaviors are related to food waste (Ghafoorifard et al., 2022; Grier-Welch et al., 2021; Rodgers et al., 2021). The fruit and vegetable consumption variable was derived from a question asking respondents whether they have been eating more, less, or about the same amounts of fresh fruits and vegetables per day since the COVID-19 pandemic began. Similarly, the cooking variable assessed whether the respondent spent more time cooking than prior to the COVID-19 pandemic. We assessed the following sociodemographic characteristics as potential covariates: age (18–34, 35–54, and 55+), gender (male, female, and other), race/ethnicity (Hispanic, Non-Hispanic White, Non-Hispanic Black, and other or multiple), annual household income (less than $10,000, $10,000–24,999, $25,000–49,999, $50,000–74,999, $75,000–99,999, and $100,000+), educational attainment (high school or less, some college, or college degree or higher), and political affiliation (liberal, moderate, conservative, or don't know/prefer not to answer) .

Data Analysis

First, we conducted descriptive analyses of all the variables to be included in the model and evaluated their distributions, intercorrelations, and associations with the outcome variable. To provide additional context on the sample, we also conducted descriptive analysis of a subset of food pantry users' characteristics. Next, we conducted a logistic regression analysis of the outcome, with higher odds ratios (ORs) indicating a greater likelihood of reporting that they were wasting less fresh produce than usual since the COVID-19 pandemic began. After we constructed the baseline model, which included all exposure variables and covariates described earlier, we identified the final model using a stepwise backward-elimination approach. At each step, we removed the variable with the largest Wald test p-value, then performed a likelihood ratio test (LRT) to confirm that its removal did not significantly worsen model fit. Variables were dropped if the LRT p-value exceeded 0.05, and this process was repeated until all remaining variables met the retention threshold. We assessed the final model's fit and sensitivity using the Hosmer-Lemeshow test and evaluated its discriminative ability using the C-statistic (Hosmer et al., 1991). We also made some adjustments to certain variables to facilitate ease of interpretation. The fruit and vegetable consumption variable was initially coded as a three-category variable with levels "less," "same," and "more." When "same" was the reference level, the OR for "less" was close to 1.00 and did not alter significantly after adjustment. Therefore, we coded this variable as binary, with "less/same" and "more." We excluded income from the model due to high multicollinearity with the SNAP variable. We completed all analyses using SAS Studio OnDemand.

Results

There were 504 respondents in the analysis dataset. Table 1 summarizes the results of the descriptive analysis. Twenty-seven percent (27.0%) of re-

Table 1. Characteristics of the FAS3 Participants (*N* = 504)

Characteristic	*N*	%
Throwing away less produce		
Yes	136	27.0
No	368	73.0
Food pantry use and produce quality		
Produce quality at food pantry is poor	58	11.5
Produce quality at food pantry is acceptable	55	10.9
Do not use a food pantry	391	77.6
SNAP/P-EBT user		
Yes	147	29.2
No	357	70.8
Spending more time cooking		
Yes	283	56.2
No	221	43.8
Eating more fruits and vegetables		
Yes	70	13.9
No	424	84.1
Unknown	10	2.0
Age		
18–34	168	33.3
35–54	158	31.4
55+	178	35.3
Gender		
Male	131	26.0
Female	364	72.2
Other	9	1.8
Race/Ethnicity		
Hispanic	40	7.9
Non-Hispanic White	380	75.4
Non-Hispanic Black	48	9.5
Other/Multiple	36	7.1
Household Income		
Less than $10,000	43	8.5
$10,000–24,999	68	13.5
$25,000–49,999	146	29.0
$50,000–74,999	95	18.9
$75,000–99,999	61	12.1
$100,000+	91	18.1
Education		
High school or less	146	29.0
Some college	194	38.5
College degree or higher	164	32.5
Political Affiliation		
Liberal	129	25.6
Moderate	168	33.3
Conservative	110	21.8
Don't know or prefer not to say	97	19.3

spondents reported throwing away less fresh produce since the COVID-19 pandemic began, and 22.4% of respondents used food pantries. Out of 113 food pantry users 58 (51.3%) perceived the quality of fresh produce at food pantries as poor. Approximately one-third of respondents (29.2%) were SNAP or P-EBT participants. While more than half of all respondents (56.2%) reported cooking more frequently, only 13.9% reported eating more fruits and vegetables. In terms of sociodemographic characteristics, women, adults aged 35 to 54, low-income individuals, and people of Hispanic and non-Hispanic Black race/ethnicity were overrepresented relative to the Capital Region's overall population (New York State Department of Labor, 2026).

Table 2 describes characteristics of food pantry users (n = 113). Typical food pantry users were those who became clients after the COVID-19 pandemic began (55.8%) and used one or two different food pantries (75.0%), with visits occurring once a month or less (62.2%). A majority (71.4%) consumed at least 75% of the fruits and vegetables they obtained from food pantries, with a mean consumption of 81.9%. They reported that it took an average of 3.8 days for fruits and vegetables from the food pantry to go bad.

Table 3 presents the results of the baseline and final logistic regression models for wasting less produce since the COVID-19 pandemic began (n = 494). None of the sociodemographic variables, except for the 35–54 age group, was significantly associated with the outcome variable. In the final model, food pantry users who rated produce quality as acceptable had 2.38 times the odds of wasting less produce compared with non-users of food pantries (95% CI, 1.14–4.92). SNAP/P-EBT participation (OR 1.88, 95% CI 1.16–3.28), increased cooking frequency (OR 5.79, 95% CI 3.49–9.97), increased fresh fruit and vegetable intake (OR 2.20, 95% CI 1.23–3.93), and the 35–54 age group (OR 1.81, 95% CI 1.05–3.15) were also significantly associated with wasting less produce compared to their respective reference groups. The Hosmer-Lemeshow test indicates a good model fit (p=0.7593), and the c-statistic indicates an acceptable model fit (c=0.763) (data not shown).

Discussion

Our motivation for conducting this study was to investigate whether participation in existing nutrition assistance programs during the COVID-19 pandemic had a positive or negative impact on household food waste. Through analysis of FAS3, a survey conducted in New York state's Capital Region in the last quarter of 2021, we found that since the COVID-19 pandemic, food pantry users who perceived the quality of fresh produce as acceptable were significantly more likely to report less produce waste than usual compared to non-users of food pantries. Similarly, SNAP/P-EBT participants were more likely to report less produce waste compared with non-SNAP/EBT participants. These are encouraging findings for both the public health and environmental science communities. Approximately 60% of household food waste is landfilled; therefore, any measures that reduce household food waste can potentially lessen soil and water contamination and reduce methane and carbon dioxide emissions (US EPA, 2023b).

Table 2. Characteristics of FAS3 Food Pantry Users (*n* = 113, % is for valid cases only)

Characteristic	*n*	%
Food pantry use history		
Start using it before the COVID-19 pandemic	50	44.2
Start using it since the COVID-19 pandemic	63	55.8
Number of different food pantries used		
One	56	50.0
Two	28	25.0
Three	18	16.1
Four	10	8.9
Frequency of food pantry use		
Once a month or less	69	62.2
2–3 times a month	28	25.2
Once a week or more	14	12.6
Percent of fruit and vegetables from food pantries that are eaten [a]		
0–49%	5	4.8
50–74%	25	23.8
75–99%	50	47.6
100%	25	23.8
Number of days before pantry fruits and vegetables went bad [b]		
0 day (already bad)	11	15.3
1 day	6	8.3
2 days	11	15.3
3 days	14	19.4
4 days	10	13.9
5 days or more	20	27.8

[a] The mean is 81.9% with a standard deviation of 18.9%.
[b] The mean is 3.8 days with a standard deviation of 4.4 days

Food Pantry Implications

For food pantries, our findings highlight the importance of maintaining the quality of fresh produce at the level their clients perceive as acceptable. Food pantry clients desire higher-quality food, including nutritious items and food that is not close to expiration (Long et al., 2023). A food item not being "good enough" in consumers' assessment has been identified as the primary reason for food waste (Aschemann-Witzel et al., 2019). During the pandemic, the New York State government implemented "Nourish New York," a program to redistribute surplus fresh produce and other farm products to food pantries (New York State Department of Agriculture and Markets, n.d.). The program increased the volume of donated fresh produce; however, it is very likely that some food pantries were not fully prepared to keep them in good quality, mainly due to staff/volunteer shortage and a lack of refrigeration equipment and cold storage (Huang et al., 2023; Wetherill et al., 2019; Winkler et al., 2023). In our study, slightly more than half of food pantry clients rated their food pantry's fresh produce as "poor quality," and nearly a quarter of clients reported that fresh produce went bad within a day. It is also noteworthy that most food pantries in the study area operated with the client-choice model before the pandemic (Winkler et al., 2023). However, public health measures to reduce community transmission of COVID-19 forced food pantries to switch to the fixed-bundle model (also known as the prepackaged-bag model) (Larison et al., 2021; Winkler et al., 2023). The fixed-bundle model has been associated with greater household

food waste (Pruden et al., 2020). Despite reduced client choices, our study provides evidence that food pantries can help reduce produce waste, provided they maintain fresh produce quality at or above acceptable levels.

Table 3. Results of the Logistic Regression Analysis for Throwing Away Less Produce Since the COVID-19 Pandemic: FAS3 data (*N* = 494)

Variable	Baseline Model OR95% CI	Final Model OR95% CI
Food pantry produce quality		
Produce quality at food pantry is poor	1.960.99–3.91	1.960.99–3.92
Produce quality at food pantry is acceptable	2.241.06–4.74	2.381.14–4.92
Do not use a food pantry	1.00REF	1.00REF
SNAP User		
Yes	1.721.00–2.96	1.881.16–3.28
No	1.00REF	1.00REF
Spending more time cooking		
Yes	6.263.65–10.72	5.793.49–9.97
No	1.00REF	1.00REF
Eating more fruits and vegetables		
Yes	2.261.26–4.06	2.201.23–3.93
No	1.00REF	1.00REF
Age		
18–34	1.00REF	1.00REF
35–54	1.961.10–3.51	1.811.05–3.15
55+	1.630.87–3.05	1.550.86–2.66
Gender		
Male	1.00REF	
Female	0.930.53–1.62	
Other	0.520.07–3.67	
Race/Ethnicity		
Hispanic	1.00REF	
Non-Hispanic White	1.130.49–2.63	
Non-Hispanic Black	1.470.52–4.16	
Other/Multiple	1.390.45–4.27	
Education		
High school or less	1.00REF	
Some college	0.830.48–1.46	
College degree or higher	0.620.33–1.19	
Political Affiliation		
Liberal	1.00REF	
Moderate	1.080.6–1.97	
Conservative	0.800.4–1.59	
Don't know or prefer not to say	1.030.51–2.09	

OR: Odds Ratio, CI: Confidence Interval, REF: Referent

SNAP Implications

Literature that focuses on SNAP and household food waste is limited and inconsistent. A study that employed mathematical models estimated that SNAP would substantially increase food purchases, leading to greater food waste (Yu & Fan, 2023). In contrast, another study that used a different modeling technique estimated that SNAP would significantly reduce household food waste (Yu & Jaenicke, 2020). These existing studies used pre-pandemic data and did not factor in the expansion of SNAP during the pandemic, which enrolled more higher-income individuals and provided greater benefits (Restrepo, 2023). Moreover, New York state was one of five states that introduced an online SNAP food purchase program before the COVID-19 pandemic and continued it during the pandemic (Kinsey et al., 2020). Our study's association between SNAP/P-EBT and reduced produce waste might have been influenced by pandemic-specific SNAP provisions that enabled participants to purchase desirable, high-quality fresh produce. In addition, our study's findings on the relationships between increased fruit and vegetable consumption, increased home cooking, and less food waste are consistent with the literature (Ghafoorifard et al., 2022; Grier-Welch et al., 2021; Rodgers et al., 2021).

Strengths and Limitations

This study has several strengths. The dataset included approximately 500 respondents, with oversampling of low-income individuals, enabling us to conduct analyses with adequate statistical

power and adjust for sociodemographic covariates. The questionnaire we used was pilot-tested, and its key construct domains had reasonably high internal validity (Niles et al., 2021). The outcome and some independent variables were assessed retrospectively; thus, we were able to account for temporality in the analysis. Finally, this study is among the few that directly evaluated the association between nutrition assistance programs and household food waste.

This study also has limitations. The oversampling of low-income individuals limits the generalizability of the results to the study population. FAS3 was administered online via Qualtrics, which may have limited participation among those without digital literacy skills or regular internet access. Those without regular internet access tend to be older, less educated, rural adults (Hargittai et al., 2019). All behavioral variables used in this study were based on self-report and may be subject to recall and social desirability biases (Fadnes et al., 2008). Moreover, these variables were relative measures (e.g., less or more, increased or decreased), and no absolute quantities, volumes, or frequencies were obtained. Nonetheless, these measures were obtained with minimal respondent burden and are appropriate for an exploratory study.

Conclusion

In conclusion, this study suggests that nutrition assistance programs during the COVID-19 pandemic may have led to beneficial outcomes despite increased food insecurity: they not only swiftly expanded access to fresh fruit and vegetables but also likely reduced household waste of these items among participants. For food pantries, this was achieved when the fresh produce provided was of acceptable quality to their clients. Improving the quality of fresh produce in food pantries remains an ongoing issue that requires attention. Several studies provide valuable "lessons learned" and insights about this subject (Huang et al., 2023; Larison et al., 2021; Long et al., 2023; Pruden et al., 2020; Wetherill et al., 2019; Winkler et al., 2023). Additionally, educating food pantry staff and clients on the meaning of food date labels on pre-cut fruits and vegetables can prevent discarding those that are still safe to consume (Neff, et al., 2019)

Moving forward, recognizing that participation in nutrition assistance programs is associated with reduced household waste of nutritious food during times of distress may help promote transdisciplinary research collaboration. Food waste research, where the major focus is on agri-food systems and their environmental impacts, and public health nutrition research have not been well integrated in the U.S. and elsewhere, even though they share the same goals of efficiently distributing healthy food, reducing food waste, and eliminating hunger (Santeramo & Lamonaca, 2021). We suggest expanding the collaboration with stakeholders from other sectors of the food system—food production, food processing, food retail, and food service—to advance this agenda through evidence-based and scenario analyses.

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Make every bite count: Can reduced food waste sustain free school meals in South Carolina?

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Abstract

Recent federal cuts to the Supplemental Nutrition Assistance Program could reduce children's access to free school meals by affecting schools' eligibility for the Community Eligibility Provision program. In this study, we examine whether food waste reduction can be used as a strategy to sustain meal programs in South Carolina. Using direct weighing waste data and surveys, we assess potential cost savings, reinvestment opportunities, and meal quality improvements.

Keywords

Community Eligibility Provision, food waste, free or reduced-price lunch

Introduction

It is expected that recently passed cuts to the Supplemental Nutrition Assistance Program (SNAP) in the budget reconciliation law (An act to provide for reconciliation pursuant to title II of H. Con. Res. 14, 2025) will affect schools' ability to implement the Community Eligibility Provision (CEP), a federal program that allows schools to provide free meals to all students. Currently, some

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schools can participate in CEP if at least 25% of students are certified for free and reduced-price lunch, such as those who receive Medicaid and participate in SNAP. However, SNAP cuts may lead to fewer families qualifying for SNAP and thus cause some children to lose their automatic eligibility for free school meals. Raising the CEP threshold to 60% has also been considered (Food Research & Action Center, 2025, p. 33), which would disqualify over half of the current CEP schools. Such a change could affect about 24,000 schools nationwide, potentially reducing meal access for about 12 million children (Center on Budget and Policy Priorities, 2025, para. 5).

South Carolina (SC), which ranks among the top states for students qualifying for free and reduced-price lunch, had approximately 70% of students eligible during the 2022–2023 school year. Potential changes to the CEP threaten equitable access to nutritious school meals for 351 schools across 31 school districts across the state, resulting in 246,009 public school students losing eligibility for free meals (Food Research & Action Center [FRAC] & Center on Budget and Policy Priorities, 2025). While states such as SC are exploring alternative funding solutions, our study investigates whether reducing food waste in school meals can generate cost savings and potentially be a viable strategy to sustain free meal school programs or improve meal quality amid declining federal support.

Our research objectives are threefold: (i) to estimate the amount of food potentially wasted in SC school lunches and the cost savings the federal government could achieve by reducing food waste in schools; (ii) to compare these savings to the costs of continuing programs such as free meals to all students through the CEP and the "Local Foods for Schools" program; and (iii) to explore parents' perspectives on food waste and the role of school meal offerings, with a particular focus on children's access to local and organic food products.

Applied Research Methods

This section describes the methods used to collect and analyze data for the study. We first outline the approaches used to measure food waste, followed by the parent survey design and data collection procedures.

Measurement of Food Waste

To estimate the percentage of food served to children that is ultimately wasted, we combine both direct weighing and self-reported survey methods. Direct weighing involves physically measuring the amount of food discarded after meals. It is widely used as the most accurate approach for quantifying food waste, although it can be time-consuming and labor-intensive (Roe et al., 2018). In contrast, self-reported surveys measure food waste by collecting respondents' estimates or perceptions of food waste. Using self-reported methods can provide insights into individual behavior but can be susceptible to reporting bias (Li et al., 2023). In this study, we integrate the two approaches to capture both objective measures of actual waste and subjective perceptions of food waste, thus enhancing the validity and comprehensiveness of our initial estimates. Specifically, we directly measured food waste during lunch periods using the weighing method and conducted surveys among parents to obtain their estimates of food waste.

Parent Survey

Following institutional review board approval (IRB2024-0711), we conducted a survey among parents (U.S. adults aged 18 and older who have children enrolled in elementary school). The survey was distributed through multiple outlets across three elementary schools in upstate SC,[1] yielding 61 valid responses. The survey was distributed via a QR code and flyers shared through school communication channels, including newsletters sent by principals to parents. Additional recruitment occurred through a booth at a school community event, a booth at the school fall festival, and in-person outreach during a Parent-Teacher Organization (PTO) meeting. Respondents estimated the percentage of school lunch waste on any given day by selecting from predefined ranges, which serves

[1] The Upstate region of South Carolina is defined as the counties of Abbeville, Anderson, Cherokee, Greenville, Greenwood, Laurens, McCormick, Oconee, Pickens, Spartanburg, and Union.

as the self-reported approach for food waste.

In addition, we included questions to evaluate how elementary school parents perceive the inclusion of local and organic products in school meals. Local food procurement by schools has been linked to potential benefits for both schools and local farmers, and although school procurement initiatives may prioritize proximity over organic status, there is public interest in supporting farmers transitioning to alternative farming systems, including organic production (Fitzsimmons & O'Hara, 2019; Izumi et al., 2010). Specifically, our survey asked about parents' purchasing behavior regarding organic products, such as their knowledge and frequency of buying organic items, as well as their opinions on increasing the availability of organic options in school meals. Additionally, we collected demographic information, including age, household size, and the grade level of their children.

Results

This section presents the findings from the direct food waste measurements and the parent survey. We first estimate the level of food waste in South Carolina elementary schools and then examine its economic implications and parents' attitudes toward school meals and organic food.

Figure 1. Free Student Meal Advertisement (top left), Lunch Assembly Process (top right), and an Example of a Completed Lunch in a School Tray (bottom) at an Elementary School in Upstate South Carolina, on September 5, 2024

Estimating Food Waste in South Carolina's Elementary Schools

Direct Weighing

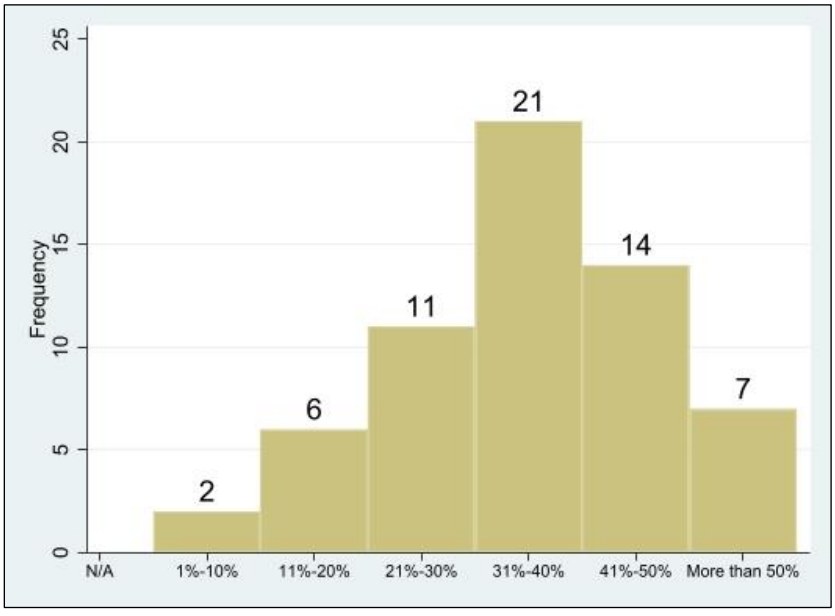
For the direct-weighing approach, we conducted a field visit to an elementary school cafeteria in upstate SC, during the lunch period (10:00 AM to 1:00 PM). The cafeteria offers three daily entrée options that contain grains or protein, with a complete meal comprising grains, an optional protein, a required fruit or vegetable, and a choice of flavored or unflavored milk (Figure 1). On the day of our visit, the entrée choices were a traditional cheeseburger (Choice A), a mashed potatoes and chicken bowl (Choice B), and a sunflower and grape jelly sandwich (Choice C). Monthly menus are available online, and students

indicate their entrée selection to teachers daily before lunchtime. To estimate the total weight of food served, we used the teachers' notes on student selections, along with interviews with the school principal and lunchroom staff. On that day, students could choose either baked beans or seasonal vegetables to satisfy the required vegetable component of the meal. Based on this information, we assumed that 80% of students selected baked beans and 20% selected seasonal vegetables.. Additionally, we assumed that all students picked a dinner roll, two fruit cups, and a 205 g milk container, consuming approximately 75% of the milk on average. That day, 68% of students chose Choice A, 16% selected Choice B, and 16% opted for Choice C, resulting in an estimated entrée weight of 50.7 kg (32.3 kg of Choice A, 11.0 kg of Choice B, and 7.4 kg of Choice C). Combined with 89.4 kg of fruit, 30.0 kg of vegetables, 13.4 kg of dinner rolls, and 91.4 kg of milk, the total estimated weight of food served was 275 kg. To assess the total weight of food wasted, we measured the weight of discarded food along with utensils and packaging, including milk containers, paper napkins, forks, and fruit cups. The discarded food was collected in trash bags and weighed in the kitchen during the lunch period as students completed their meals and each bag reached capacity. The utensils and packaging were collected during lunch and then weighed in a university research laboratory using an Ohaus semi-micro balance with a readability of 0.01 mg (10 micrograms). After subtracting the estimated weight of discarded utensils and packaging (13 kg) from the total weight of the trash (108 kg), we found that food waste totaled 95 kg. This indicates that 65.5% of the food served that day was consumed (180 kg out of 275 kg), while approximately 34.5% was wasted (95 kg out of 275 kg). Furthermore, we estimated that milk contributed approximately 24% of the total food waste by weight. Food waste estimates can fluctuate depending on the daily entrée options available, and on the day of our visit, the cheeseburger was the most popular choice among students.

Self-Reported Survey

For the self-reported approach, as illustrated in Figure 2, all respondents acknowledged the presence of food waste, with approximately 69% estimating that children discard more than 31% of their meals. To approximate the average reported waste, we assigned the midpoint of each range (e.g., 5.5% for the 1%–10% category, 15.5% for the 11%–20% category, 25.5% for the 21%–30% category, 35.5% for the 31%–40% category, and 45.5% for the 41%–50% category) and calculated a weighted average using the number of responses in each category. For the "more than 50%" category, we conservatively assigned a midpoint value of 55%. Using these midpoint values and the response frequency shown in Figure 2, the average reported waste was approximately 34.7%, closely aligning with the 34.5% estimated through the direct weighing approach. Given this consistency between direct weighing and self-reported survey estimates, we adopted a 35% food waste estimate as the foundation for all subsequent cost analyses.

Figure 2. Distribution of Reported Food Waste Percentages in School Meals Across Three Elementary Schools in Upstate SC



This close alignment between the two independent measurement approaches provides additional confidence in the validity of the estimated waste level.

Cost Implications

Given our 35% food waste estimate, we find that $1.55 of every $4.43 spent[2] per school meal may be ultimately wasted, based on the National School Lunch Program (NSLP) reimbursement rates for the 2024–25 school year (School Nutrition Association, n.d., "Federal Reimbursement Rates for SY2024–25"). We assume that approximately 59% of all public-school students (about 473,000 students) in SC benefit from the Free or Reduced-Price Lunch (FRPL) program daily (SC Department of Education, n.d.-a).[3] Since 349,501 out of 796,780 public school students (about 44%) were enrolled in elementary school (grades 1 through 6) in 2024–2025 (135-day active headcount) (SC Department of Education, n.d.-b), we estimate that up to 207,458 elementary school children may participate in the FRPL program each day. This program is crucial in ensuring food access, including fruits and vegetables, for children who might otherwise lack it. However, if 100% of the 207,458 elementary school children enrolled in the FRPL program receive a free lunch each day and $1.55 of every meal is wasted across SC elementary schools, this amounts to approximately $321,663 wasted every school day, equating to a loss of about $59.90 million every school year (Table 1).

Since the FRPL estimate includes both free and reduced-price recipients, and our analysis focuses specifically on federal savings, we further adjust our food waste cost estimates by considering varying assumptions regarding the proportion of students receiving fully funded (free) meals. Moreover, because 100% food waste reduction may not be a viable goal, we consider varying assumptions regarding the percentage of reduced food waste. We examine scenarios where these shares range from 25% to 100%, in 25% intervals, to explore potential monetary impacts of food waste reduction.

As illustrated in Table 2, if 25% of the FRPL-enrolled elementary school students (207,458 × 25% = 51,865) receive free meals, and total food waste is reduced by 25% ($1.55 × 25% = $0.39), the potential savings in SC over the standard 180 school days per year would total approximately $3.6 million (51,865 × $0.39 × 180). If all food waste were eliminated and all elementary school students received free meals, savings could reach $57.9 million. While achieving maximum savings is

Table 1. Preliminary Estimates of Food Waste in Elementary Schools Across South Carolina [a]

Estimated % of food wasted from meals served	35%
Cost per meal	$4.43
Estimated wasted dollars per meal	$1.55
Enrollment of all public-school students	796,780
Enrollment of public elementary schools only (Grades 1–6)	349,501
Share of students enrolled in public elementary schools (Grades 1–6)	43.86%
Enrollment of FRPL SC per day	473,000
Estimated enrollment of FRPL in SC per day: elementary school student (Grades 1–6)	207,458
Cost of food waste in SC per school day	$321,663
Cost of food waste in SC per school year (180 days)	$57,899,397

[a] All currency in U.S. dollars (US$). Data sources: Original survey conducted September–November 2024 and March 2025 (n = 61); cost-per-meal and student enrollment data from the South Carolina Department of Education.

[2] All currency mentioned in this article is in U.S. dollars (US$).

[3] This assumption falls between state and federal estimates. State reports indicate a lower rate of students receiving subsidized meals in 2021–22, such as 47% (SC Department of Education, n.d.-c), possibly because they count only directly certified students enrolled through safety-net programs. By contrast, federal estimates are closer to 70%, potentially because they incorporate Community Eligibility Provision (CEP) multipliers.

unlikely, our sensitivity analysis shows that even a modest 25% reduction in food waste could significantly impact resource allocation and contribute to the sustainability and quality of meal programs in SC elementary schools. Many schools in upstate SC offer free meals to all enrolled students. The last column of Table 2 represents a reality where all elementary schools in SC behave as in this school district, where savings would range from $14.5 million yearly (with food waste reduction of 25%) to $58 million yearly (with food waste reduction of 100%).

Leveraging Food Waste Reduction to Sustain Free Meals and Other Programs

Savings from reduced food waste could be reinvested to expand meal access, helping to sustain free and reduced-price meal programs for low-income students. Based on our preliminary 35% food waste estimate, we find that $1.55 of every $4.43 spent per school meal may be ultimately wasted. Our most conservative estimate in Table 2 indicates that reducing total food waste by 25% could lower the cost per meal to $4.04 ($4.43 – $0.39). This reduction would allow one additional free meal to be provided for every 10.36 students ($0.39 × 10.36 = $4.04). In practical terms, if all elementary school students enrolled in the FRPL program receive free lunch, approximately 20,027 additional meals (207,458 ÷ 10.36) could be provided, feeding up to 111 more children each school year. Alternatively, a complete elimination of food waste (100% reduction) would drive the cost per meal down to $2.88 ($4.43 – $1.55). Under this scenario, one additional free meal could be provided for every 1.86 students ($2.88 = 1.86 × $1.55). This would result in approximately 111,653 additional meals (207,458 ÷ 1.86), feeding up to 620 more children each school year.

Savings from reduced food waste could also be reinvested to improve meal quality and strengthen connections between students and their local community. This funding could help sustain the availability of local food options despite the termination of the U.S. Department of Agriculture's (USDA) $660 million Local Foods for Schools program, which was set to distribute funds across 40 states for fiscal year 2025. Currently, the USDA's support for local food initiatives plays a significant role in students' access to local food in school meals. For example, in 2022, the USDA Agricultural Marketing Service (AMS) entered a cooperative agreement with SC, providing more than $3.1 million to increase the purchase of nutritious, locally sourced foods for school meal programs (USDA AMS, 2022). Congress could also establish similar funding mechanisms to expand state initiatives such as South Carolina's Certified SC Cafeteria program.

Lastly, savings from reduced food waste could be reinvested to improve access to organic produce for children from low-income families. As discussed in the next section, our survey indicates that the parents of elementary school children highly value the inclusion of organic food both at home and in school settings. However, cost remains the primary barrier, making school meals the only opportunity for children from low-income households to access any type of organically produced food.

Table 2. Preliminary Estimates of Annual Savings (in U.S. dollars) Based on a 180-Day School Year across Varying Levels of Food Waste Reduction and Student Participation Rates in the Free School Lunch Program

			% and # of Free Lunch (of FRPL-enrolled)			
	%	$	25% (51,865)	50% (103,729)	75% (155,594)	100% (207,458)
% of reduced food waste	25%	$0.39	$3,618,715	$7,237,432	$10,856,147	$14,474,863
	50%	$0.78	$7,237,431	$14,474,863	$21,712,295	$28,949,727
	75%	$1.16	$10,856,147	$21,712,295	$32,568,442	$43,424,590
	100%	$1.55	$14,474,863	$28,949,727	$43,424,590	$57,899,453

[a] All currency in U.S. dollars (US$)

Children's Needs and Parents' Food Behavior

Among the 61 valid survey responses, price emerged as the most frequently considered attribute when grocery shopping (79.49%), followed by sugar-free options, avoidance of specific ingredients (such as food dyes, high-fructose corn syrup, and genetically modified organisms [GMOs]), and then organic certification.

Among respondents who selected "organic" as one of their preferred attributes, the average rank assigned to "organic" was 2.135, while "price" was ranked higher at 1.714, indicating that while organic products are valued, affordability remains the top priority. All respondents recognized the USDA Certified Organic label when shown the image; however, while over 60% reported purchasing organic food products, including vegetables, fruits, milk, or beef, only 40% specifically noted purchasing items with the USDA organic label. This discrepancy suggests that some organic purchases may come from local farmers markets or third-party sources perceived as organic but lacking formal USDA certification. When asked whether they would like to see more organic products incorporated into school meals, approximately 87% of respondents expressed support, citing the nutritional and health benefits of organic food for their children. Among those less supportive, the most cited concern was the potential higher cost associated with organic options.

Our findings indicate that younger parents (ages 20–40 vs. 40–60), those with smaller households (2–4 members vs. 5–10), and parents of younger children (kindergarten to grade 2 vs. grades 3–6) are more likely to prioritize organic options when grocery shopping, purchase organic products more frequently, and express stronger support for incorporating organic foods into school meals (Table 3). These trends may reflect a greater health-consciousness among younger parents and their attentiveness to the preferences of young children, who are often more selective or particular about their food choices (Fromm & Garton, 2013; Patrick & Nicklas, 2005; Russell et al., 2015).

Overall, parents of elementary school children value the inclusion of organic food both at home and in school settings. However, cost remains a primary concern, as organic products are often more expensive. This aligns with findings by Maubach, Hoek, and McCreanor (2009) and Hammad and Kay (2023), who observed that while parents desire healthier food for their families, various factors influence purchasing decisions. This underscores the importance of offering high-quality, low-cost (or free) food options in schools. With the potential rise in school meal costs, regardless of whether organic food is included, children from low-income households may face greater challenges in accessing nutritious meals. For many, school-provided meals represent their only opportunity to consume healthy food, and in some instances, to consume a meal at all. Efforts could focus on minimizing food waste to lower costs and help maintain the accessibility and quality of school meals for all students.

Table 3. Summary Statistics of Parents' Preferences for Organic Food Products

Survey questions (61 valid respondents)		
What food characteristics do you prioritize when buying food for your child(ren) at the store?	**Organic** 28.21%	**Price** 79.49%
Please rank the food characteristics you seek when buying food for your child(ren) at the store.	**Organic** 2.13	**Price** 1.71
Have you purchased organic food products (for example, vegetables, fruits, milk, or beef) in the last month?	**Yes** 60.66%	**No** 39.34%
Do you know this label? (USDA Certified Organic label)	**Yes** 98.36%	**No** 1.64%
You have said you know the USDA Organic label; do you try to buy products with this label when you grocery shop?	**Yes** 60.00%	**No** 40.00%
Would you like to see organic foods in school meals?	**Yes** 86.89%	**No** 13.11%

Conclusion and Future Directions

Using data from in-school food waste measurements, a survey across three elementary schools, and discussions with members of the school board of directors, county procurement

office, school principals, and Parent-Teacher Organizations (PTOs) in upstate SC, our preliminary findings show that stakeholders share similar concerns about food waste and interest in exploring strategies to reduce it. Our estimates indicate that a 25% reduction in total food waste could provide about 20,027 additional meals, and a 100% reduction (in theory, a complete elimination of food waste) could yield about 111,653 additional meals, potentially feeding between 111 and 620 more children each school year, respectively. Savings from reduced food waste could also be reinvested to improve meal quality, particularly considering the USDA's termination of the Local Foods for Schools program and our findings on parents' perceived value but limited accessibility of organic foods. By integrating insights into waste reduction with parental preferences, we aim to inform strategies for reinvesting saved resources in ways that ensure children's continued access to high-quality, nutritious meals.

In this research brief, our preliminary estimates suggest that potential savings from food waste reduction could help offset costs and sustain crucial programs such as the CEP, which allows schools to provide free meals to all students, and the Local Foods for Schools program or similar iniatives in SC, both essential for elementary school children to access nutritious and healthy food in school meals. However, these estimates should be interpreted with caution. The food waste measurements were conducted in a single elementary school and the survey responses were collected from three schools in one district, which may not fully capture the variation across schools and districts statewide. Therefore, the statewide cost estimates presented in this study should be viewed as illustrative scenario-based estimates rather than precise forecasts.

At the same time, accurately measuring food waste is a challenge in itself (Bellemare et al., 2017). Our future research seeks to enhance the measurement of food waste in school cafeterias by combining multiple approaches: tray-level digital imaging to estimate consumption and waste at the item level, smart bin weight sensors to track discarded food in real time, integration of waste data with cafeteria administrative records (e.g., meals served and menu composition), and repeated behavioral observations to monitor patterns over time. By triangulating all these methodologies, we seek to produce more reliable and policy-relevant estimates, evaluate the effectiveness of targeted interventions in elementary schools, and establish practical and achievable reduction goals for food waste reduction.

Potential interventions for reducing food waste in schools include launching schoolwide awareness campaigns, integrating food and nutrition education into the curriculum, and encouraging student participation in waste reduction initiatives (Broad Leib et al., 2016). These efforts could not only foster responsible consumption habits in schools but also empower students to carry these behaviors into their homes, promoting waste reduction beyond the school setting. Additionally, schools can implement practical solutions such as "offer versus serve" models (Ishdorj et al., 2015), which provide students with greater choice in their meal selections (Nguyen et al., 2023); adjusting lunch schedules to optimize food consumption; and establishing "share tables" where uneaten food can be redistributed rather than discarded (USDA, 2016). Schools may also consider strengthening partnerships with local producers to support local and regional food systems and potentially reduce procurement costs, while incorporating locally sourced conventional or organic menu items that align with parents' preferences and reduce the barriers identified in this study.

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Formative research on strategies to improve food donation in grocery retail

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Abstract

Over one third of food produced in the U.S. goes unsold or uneaten, including a large portion of high-quality food that could be donated to individuals utilizing the charitable food system. This formative research study explored barriers to donation and created strategies to improve donation among frontline grocery retailer workers. In this study, we conducted in-depth interviews with grocery retail workers (n = 28), corporate leadership (n = 6), and donation partners (n = 5), and a series of in-person meetings with a cohort of 10 frontline worker "Champions" from a large U.S. grocery retail chain to identify common barriers to food donation and co-design strategies to reduce wasted food and improve food donation in their stores. We created four strategies: (1) conduct new

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trainings; (2) utilize updated donation guidelines with posters and detailed handouts; (3) strengthen connections between donation partners, associates, and stores; and (4) run a donation incentives contest. Additionally, Champions highlighted the need for open, clear, timely, accessible, and reciprocal communication and feedback as essential to the success of all four strategies. As organic waste ban policies expand, grocery retailers will need to increase the use of alternative solutions, such as donating, to manage surplus food. This project breaks new ground by not only working to identify and address the barriers faced and prioritized by frontline workers, but also by centering the workers themselves to create responsive strategies.

Keywords
human-centered design, participatory research, qualitative methods, food donation, wasted food, grocery retail

Introduction

Nearly one in seven U.S. households experiences food insecurity, or not having enough food for an active, healthy life (Rabbitt et al., 2025). Although eliminating food insecurity would require systemic changes and a fundamental shift toward sustainable food systems and economic development (Holt-Giménez, 2019), many interventions currently exist to alleviate food insecurity. In the U.S., food insecurity is addressed via two main strategies: distribution of economic benefits (e.g., Supplemental Nutrition Assistance Program) and direct provision of charitable foods. The charitable food system provides food to over 40 million people per year (UConn Rudd Center for Food Policy and Health, n.d.). Food banks and direct distribution partners (e.g., food pantries, soup kitchens) rely heavily on donations from corporate grocery retailers, manufacturers, wholesalers, and farmers. Despite these efforts, there is still a significant portion of safe and nutritious food that could be, but currently is not, donated. This paper focuses on strategies to improve the efficiency of grocery retailers in diverting high-quality food to individuals experiencing food insecurity through the charitable food system.

Surplus Food and Wasted Food in Grocery Retail

Over one third of food produced by the U.S. food system each year goes unsold or uneaten, defined as "surplus food." Although a small portion of this food is donated or fed to animals, the majority becomes what is defined as "wasted food," ending up in landfills, incinerators, sewers, compost piles, anaerobic digesters, spread on land, or left in the fields (ReFED, 2025). In 2023, grocery retail generated 4.5 million tons of surplus food, and although approximately one fifth was donated to local food banks and food pantries, the majority was wasted (ReFED, 2024).

Grocery retailers face financial losses from surplus food. Unsold food contributes to retail "shrink," a term used in the industry to describe the total dollar amount lost from causes other than sales (Johnston, 2023), including discarding and donating food. Shrink also includes money lost in the investment in logistics, storage, and labor for food that never gets sold (Johnston, 2023). Wasted food incurs additional costs from waste hauling and disposal fees at landfills and/or fees related to diversion to composting or anaerobic digestion companies. Shrink is generally used as a key indicator of departmental, store, and retailer performance (Teller et al., 2018).

There is a growing body of literature focused on reducing surplus food in grocery retail, including improving forecasting for more accurate ordering, enhancing food packaging, and changing consumers' buying habits (De Moraes et al., 2020; Filimonau & Gherbin, 2020; Huang et al., 2021;

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Conflicts of Interest
The authors have no competing interests to declare that are relevant to the content of this article.

Riesenegger et al., 2023). These studies focus primarily on prevention of wasted food, which aligns with best practices outlined by the U.S. Environmental Protection Agency Wasted Food Scale (U.S. EPA, 2026). However, grocery retailers face a dilemma; surplus food is regarded as a natural side effect in retail corporations, who aim to offer a broad variety of products and ensure product quality. Customer demands drive retailers to prioritize availability, uniformity, and variety of products, as well as displays that provide a perception of overflowing abundance (Riesenegger & Hübner, 2022). Many retailers also maintain brand protection through high standards for freshness of the foods they sell.

Food Donation in Grocery Retail

To manage surplus food, grocery retailers turn to food donation, which substantially cuts waste hauling and diversion costs. Additionally, many retailers include food donation in their Environmental, Social, Governance plans, which contain written commitments to benefit local communities and the environment. Donation in grocery retail happens in two steps. First, frontline workers pull foods from shelves and store them, usually by refrigeration or freezing. Typically, foods that are close to, but not yet past, the date on the date label are donated. In contrast, foods that are perceived to be past their prime or that have passed the date on the date label, are thrown away. Next, food must be transported from the individual stores to local food donation partners (e.g., food banks and food pantries). Stores make contracts with food donation partners to pick up food on a regular basis (e.g., one or two times per week).

Successful donation depends on communication and coordination across multiple operational and logistical steps. Store-level data on the quality and types of foods wasted in grocery retail is proprietary and therefore difficult to access, so it is not publicly known how much food that is currently wasted could be donated. However, retailers follow strict standards of item appearance and shape. As a result, there is likely a large amount of edible and high-quality food that could be donated. Additionally, there is likely wide variability across retailers and stores in the amount of food that is donated, based on differences in corporate and store-level operations and expectations, in addition to frontline workers' knowledge and expertise, buy-in, and ability to complete required tasks.

To our knowledge, no previous research has focused on improving the food donation process in grocery retail stores. A few studies have focused on the practicalities of implementing solutions to wasted food, including involving those most involved in wasted food management, such as store managers (Gruber et al., 2016) and frontline workers (Ceryes et al., 2021). Further, three projects led by the Pacific Coast Food Waste Commitment (PCFWC) engaged frontline workers in the process of developing solutions to reduce wasted food (Packer, 2025; PCFWC, 2022, 2024). However, these studies and projects were not conducted in grocery retail settings nor did they focus specifically on improving the donation process.

Current Study

In this paper, we describe the results of a study conducted in partnership with "Company X," a U.S. grocery retail company that operates stores in over half of U.S. states. Company X operates a food donation program, a companywide initiative that aims to donate edible food that might otherwise be discarded. The program was initially introduced several years ago. However, after the COVID-19 pandemic, the company began implementing an updated version of its food donation program across all stores. Even after the updates, some stores continued donating few or no products. Through the Food Donation Champions project, Johns Hopkins University, the Maryland Institute College of Art, and Company X collaborated to explore and address this issue. We convened 10 frontline workers (henceforth, Food Donation Champions, or Champions) from four stores in the company's Eastern Seaboard region to explore the existing food donation program and identify strategies to improve in-store utilization of the program by frontline workers.

We answer the following questions: (1) What are common barriers to food donation faced by frontline workers? (2) What strategies do frontline workers recommend to reduce wasted food and improve food donation in their stores?

Materials and Methods

We previously published a full description of methods elsewhere that describes our process, including epistemology, positionality, sampling, participant engagement, data collection, and data analysis (Harper et al., 2025). To avoid duplication, we provide a brief explanation of methods below.

Approach

This project combined research methods from design, public health, and anthropology (National Science Foundation, 2024), and followed the human-centered design (HCD) process (IDEO.org, 2015). HCD is a collaborative, creative process dedicated to understanding the experiences of people at the heart of an issue or problem and designing interventions that better serve their needs and/or alleviate challenges they are facing (IDEO.org, 2015). HCD views problems through the perspective of the people directly impacted by a problem (in this case, the Champions), positions their lived experience as expertise, and involves them as co-creators and experts throughout the design process.

Participants

Company X selected four stores in the Eastern Seaboard region to participate in this study. Selected stores were in urban (n = 1), rural (n = 2), and suburban (n = 1) communities and had various sales volumes (i.e., high-volume stores sell more than low-volume stores). Additionally, the four stores were selected because they either donated no items or inconsistently participated in the program prior to the beginning of the study. Throughout the study, we collected data from four groups of participants: (1) Food Donation Champions (n = 10); (2) Non-Champion workers, including frontline workers and store directors (n = 20); (3) members of Company X national- and regional-level corporate leadership whose main jobs or components of their jobs focused on food waste reduction (n = 6); and (4) donation partners, which included food banks and/or pantries who picked up and distributed donated food from the four stores in the study (n = 5). Recruitment began in May 2023 and ended in August 2023.

Data Collection and Analysis

We conducted in-store research between June 2023 and August 2023, and members of the research team visited each study store five times during this period. Each visit lasted between two and four hours. At each visit, we conducted two to three in-depth interviews for a total of 30 interviews. We also participated in "interactive observations" during each store visit, in which members of the research team were led around the department and/or store by a worker to describe and illustrate their daily tasks. We also conducted unstructured interviews with five donation partners, including at least one who received food from each study store. Finally, we conducted interviews with six members of corporate leadership at various levels (national, regional, and subregional). We synthesized data using deductive and inductive thematic analysis (Proudfoot, 2022).

We held six in-person meetings with Champions over the 10-month study period. Meetings aligned with the steps of the HCD process (IDEO.org, 2015): initial research (two meetings), synthesis, ideation, prototyping, and sharing results. During these meetings, Champions helped the research team with data collection and analysis, including creating and reviewing in-depth interview guides and assisting with the synthesis and interpretation of data. Additionally, Champions brainstormed solutions and collaboratively developed prototypes that aimed to reduce wasted food and improve food donation. The research team tested the desirability, usability, and feasibility of each prototype in stores with Champions before finalizing the prototypes into the four strategies and one recommendation presented in this paper. Champions and the research team co-presented the results of the study to Company X corporate leadership at the final in-person meeting.

This research was determined exempt by the Johns Hopkins University Institutional Review Board (IRB #24459). The IRB approved the use of oral consent procedures in lieu of written consent and approved all oral consent forms. Oral consent was obtained by researchers during the first meeting with Champions and at the beginning of individual interviews with each participant.

Results

In the following sections, organized based on the four final strategies and one recommendation co-created by Champions and researchers, we (1) describe the barriers to donation described by the Champions, non-Champions, Company X leadership, and donation partners; and (2) outline the strategies co-designed by Champions and the research team to respond to these issues.

Strategy 1: Conduct New Trainings for the Food Donation Program

The first strategy involved conducting new trainings for all company employees to better understand and implement the food donation program.

Barriers to Donation

Although workers use date labels to decide what foods may be fit or unfit for sale, they were unsure if these rules always corresponded to what foods may be donated. Workers felt that they received unclear guidance from corporate leadership and used their own knowledge and expertise of food safety protocols, as well as their subjective judgment and personal values, to determine if an item close to or past its date label was safe and fresh enough to donate. For example, many workers opted to discard food rather than donate it, largely citing personal judgment calls ("I wouldn't feed that to my family" [Store 1, Department Manager]) and potential safety concerns. Additionally, individuals in each department had differing opinions on what should be donated, as well as varying levels of understanding and buy-in to the donation program. This led to differences in the types and quality of foods being donated.

Although there was an updated training for the food donation program in recent years, workers said that it provided insufficient guidance. Specifically, they noted that the training, which was conducted virtually with approximately 200 department managers across the region, did not provide adequate details about program processes and did not offer adequate time for workers to ask questions. Additionally, workers felt that there was insufficient training of regional- and subregional-level leadership. They noted that, because corporate leadership was largely unaware of the program, there was an overall weak company culture around donations, which included inconsistent messaging about whether workers should be donating consistently and how much they should be donating. Many workers described feeling confused about whether increasing donations was viewed positively or negatively by the company. Some department-level workers noted that they were actively discouraged or even reprimanded by their bosses for donating because increasing donations was perceived as increasing shrink, whereas others were rebuked for not donating at all:

> I mean, shrink is shrink. It doesn't matter if it's [discarded] or donated. If it's not sold, it's shrink. [Store 3, Department Manager, referring to a perception of corporate views]

Additionally, workers in some departments noted that their performance was evaluated both based on their ability to produce the exact numbers of items dictated by the in-store production software and to sell all the items they produced. However, some workers expressed frustration about being required to produce certain numbers of items despite knowing these items were unpopular among customers. They noted that, when the products did not sell, they were then reprimanded for overproducing.

Many workers at the department level also felt unsure about whom to ask when they had questions about the donation program; they said that their managers typically did not know:

> I think we had a virtual meeting [for the food donation program roll out] and we went through it, but it was very, very vague. We had a lot of questions. We were reaching out, like we were reaching out to people, and [...] they didn't have the answers. [Store 1, Department Manager]

Workers perceived this problem as reflecting insufficient training at the leadership level.

Strategy to Improve Donation

To address these challenges, the Champions recommended that the company conduct new train-

ings about the food donation program for all employees at *all* levels to align communication, expectations, and processes. They noted that such trainings would strengthen the culture of donation by demonstrating leadership's commitment to the program and would build worker motivation and engagement.

The Champions helped create preliminary curricula (Appendix A) for eight training modules adapted to the needs of subregional, regional, and national corporate leadership, as well as regional department specialists, store directors, department managers, inventory managers, and cashiers and courtesy clerks. The trainings cover the following topics: the importance of the food donation program; donation food safety and quality; food donation processes; challenges faced by frontline workers; participation in donation contests and incentives; strengthening connections with donation partners; and roles, responsibilities, and chain of command. The Champions felt strongly that for department managers and their direct supervisors, training should be hands-on, noting that this would be most effective in building knowledge and keeping workers engaged. Additionally, the Champions noted that it was important to include time for those being trained to ask questions and provide feedback about their experiences working with the program.

Members of corporate leadership were in favor of additional trainings to clarify the donation process, but they felt that the strategy created by workers was too intensive. Specifically, they noted that only store-level workers should receive the training "because corporate should already know the process." They also noted that in-person trainings may be logistically difficult and too costly to conduct.

Strategy 2: Utilize Updated Donation Guidelines with Posters and Detailed Handouts

The second strategy involved utilizing posters and informational handouts to educate and remind in-store workers about Company X's updated donation guidelines.

Barriers to Donation

In addition to enhanced training, many workers wanted a daily reference they could use to inform or remind them of which items may be donated. Although the company had provided written guidelines after the initial training, most workers we talked to did not know about the guidelines or how to access them. Those who did have a copy of the guidelines felt that they were confusing, did not apply to their department, contradicted what they had been instructed to do in their stores, or contradicted their own ideas about what to donate (e.g., noting that food could still be safely eaten after its sell-by date). Additionally, we observed that the donation guidelines were not standardized across stores or clearly understood by all workers. For example, laminated signs in the bakery departments of two stores we visited explicitly stated that cakes may not be donated, but department managers at the other two stores did not have signs and regularly donated cakes.

Members of corporate leadership recognized that workers needed clarity around what items could be donated. One member of corporate leadership described the situation by saying,

> It turned into "whisper down the lane" because some departments are different than others. Dairy and frozen are different, along with grocery. So, things just kind of got mixed up. [In] some of the stores, the store director printed out the guidelines, handed them out, and said, "Here, make that happen," or, "Here, start donating" [without providing additional guidance]. [Member of leadership]

Strategy to Improve Donation

To standardize information about the food donation program, the Champions recommended that the company provide posters with department-specific donation guidelines, adapted to the workers' nuanced questions (Appendix B). In addition to hanging laminated posters, departments would also keep more detailed donation handouts available for reference (Appendix C). Building on the company's earlier materials, the research team and Champions co-created new Donations Guidelines Posters and Detailed Handouts. The Guidelines Posters provide simplified overviews of donation guidelines, including item types, storage requirements, timing of donations, and what strictly should not be

donated, to be used as a quick reference when department managers pull items for donation or trash. The Detailed Handouts provide a more comprehensive description of the process and guidelines and could be used as a reference tool for complex or unusual questions about donatable items. These responded to the workers' specific questions and concerns about department-specific donation rules (e.g., which cakes can be donated, and how long can they be refrigerated or frozen before pick-up?) and the process for donating (e.g., should items be scanned before or after being placed on the reduced-price rack?). The new posters and handouts aimed to create a uniform approach to donations within and across all stores.

Members of corporate leadership were in favor of this strategy, noting that it would be realistic and cost-effective strategy that could be rolled out relatively quickly.

Strategy 3: Strengthen Connections between Donation Partners, Workers, and Stores

The third strategy involved building relationships and strengthening connections with donation partners, such as local food banks and food pantries.

Barriers to Donation

Almost all workers with whom we spoke did not know what happened to donated food after it left the store, which reduced their inclination to donate food. Further, workers expressed concerns about the maintenance of food safety protocols after the food leaves the store and about the credibility and motives of donation partners, including potential misuse of the program. They had many misconceptions about who received the food from donation partners and what they did with it. One department manager stated,

> The only thing that I can think of as a negative thing [about the donation program] is people getting it that don't need it and now they don't have to come in the store and buy food because they just received free food. Again, it's a fine line because if people don't come and buy food, I'm out of a job. [Store 4, Department Manager]

Another reported concern was that stores did not have clear and consistent information about each donation partner, including food needs and preferences, and pick-up days.

The Champions discussed these sentiments extensively at the first two in-person meetings. To address these fears and answer questions posed by the Champions, researchers visited and talked with at least one of each participating store's donation partners and presented the information gathered and pictures taken at those visits to the Champions at the third meeting. This was a turning point for many Champions, who, for the first time, learned where donated food goes, who receives it, and the conditions under which it is provided. Many noted they were deeply moved by the presentation because it revealed the real need for donated food in their own communities. They mentioned that if other workers knew more about the donation partners and saw their work firsthand, they would be less skeptical and more motivated to consistently contribute to the donation program.

Strategy to Improve Donations

The goals of this strategy were to cultivate an engaging and trusting relationship between donation partners and workers; enhance the donation culture in stores; improve transparency in the donation process; and encourage store workers at all levels to actively participate in the donation program. The Champions suggested a multipronged approach to this strategy, including (1) three distinct opportunities for workers to learn about donation partners and (2) an onboarding form for new donation partners to enhance communication about their capacity, needs, and specifications. Each approach is described in more detail below.

(1A) Paid Immersive Training with Donation Partners: In this opportunity, department managers and/or other key workers in charge of food donation would receive a fixed number of paid training hours per year designated for on-site training at one of their store's donation partner locations (e.g., local food pantry). Champions recognized that this strategy may be expensive when applied across the corporation, particularly with the tight margins in

grocery retail, and noted that one half-day (4 hours) per year would be sufficient. Activities at donation partner locations would depend on what is needed on the visit day (e.g., pantry set-up, food distribution, etc.). (See Appendix D.)

(1B) In-Store Teach-In: Recognizing that all workers would not be able to participate in the immersive trainings due to cost and logistics, Champions suggested that donation partners visit stores and deliver a 15- to 20-minute presentation similar to the one we presented at their meeting. This presentation would share information and photos about the donation partner (their mission, goals, who they serve, donation needs, etc.). These teach-ins would give all workers the chance to learn about partners and to ask questions. (See Appendix D.)

(1C) In-Store Customer-Facing Event: Champions also suggested that donation partners host customer-facing tables or booths in the front of stores. The tables would provide information about the organization and how they collaborate with the store, helping to build an understanding of community needs and strengthen buy-in for donations among both workers and customers. (Appendix D).

(2) Donation Partner Onboarding Form: In addition to the learning opportunities, Champions suggested creating a form that would collect standardized information from all donation partners at the time of onboarding. The form would serve as an acknowledgment of food safety protocols and would gather donation partner-specific information, including food needs and preferences, pick-up schedules, and interest and willingness to participate in in-store events and to host the immersive training (Appendix D).

Members of corporate leadership were receptive to some aspects of this strategy, including the in-store teach-ins and events, as well as the onboarding form. However, they noted that the paid immersive training would be too expensive and logistics would be infeasible.

Strategy 4: Run a Donation Incentive Contest

The fourth strategy involved creating and implementing a donation incentive contest for in-store workers.

Barriers to Donation

Workers and leadership both acknowledged that there was ample surplus food that could still be donated rather than thrown out. Some workers noted that if the training was enhanced and the guidelines were clearer, they would participate in the donation program simply because it is expected of them (for example, "I think most people were just doing the donations because it's a part of the job" [Store 2, Department Manager]). However, other department managers noted that they had little incentive to donate items and felt apathetic toward the donation program, noting that—even after learning about the guidelines—they still preferred to trash items that could have been donated because they perceived that they were less likely to get in trouble. Additionally, some workers felt that donating items was inconvenient and that they did not have time to do it amidst all their other expected daily tasks. Although the company sought to address this by creating a simplified process for scanning and tracking donations, workers expressed that it was still not part of their daily routine. This combination of perceived inconvenience and feelings of apathy disincentivized some workers from regularly donating.

Strategy to Improve Donation

To build motivation for consistently donating and to solidify donating as a habit, the Champions suggested the use of a donation incentive contest (Appendix E). The contest would use structured incentives to solidify behavior changes for workers involved in the food donation process. This idea originated from existing companywide contests that encourage employees to sell specific products (e.g., whichever store in the district sells the most watermelon during a certain timeframe, wins). The Champions recommended teaching workers about the contest during the enhanced trainings and running the contest consistently for at least a year after it is implemented. They noted that after one year, it may be possible to increase the time between contests or gradually phase it out altogether. Again,

workers were conscious of developing strategies that would be low-cost for the company in the long run.

During the contest, Champions suggested that each store and department work with leadership to articulate contextually appropriate weekly donation goals. Champions noted that working with leadership to develop goals would mitigate their fear of being reprimanded for donation-related shrink, because these donation goals would focus on increasing the proportion of their pre-existing shrink that is donated. For example, if the bakery currently donates 10% of their total shrink, they may set a goal to increase donations to 40% of their total shrink. These proportional goals would decrease the number of donatable items from being trashed without incentivizing workers to donate items that would otherwise be sold. Champions noted that the specific percentage goals must take into consideration store and department characteristics (e.g., a lower-volume store vs. a higher-volume store; the department type and amount of food viable for donation, such as seafood vs. deli). The donation incentive contest would operate at the store level: if all but two departments in a store meet their weekly donation goals, the store would earn a point. This rule was created in recognition that not all departments have items to donate on a weekly basis. Unlike the existing companywide contests that only reward specific department managers, for the donation incentive contest, winning stores would receive recognition as well as pizza parties or other nonmonetary incentives (e.g., in-store coupons, other free food from outside vendors).

Unlike the paid immersive training with donation partners, leadership felt that this idea was more financially feasible. They noted that providing recognition as a prize felt the most feasible, but that other incentives the workers suggested may be too costly when implemented across the company.

Additional Recommendation: Enhance Communications and Feedback Mechanisms about Donations

The Champions and other workers we spoke with described challenges related to communication and feedback, such as difficulty getting clear information about donations, delayed responses to their questions or requests regarding food donation policies and processes, and limited opportunity for input and feedback. Some workers also expressed a desire for greater receptivity to the input and ideas they provide. The researchers and Champions recognized that enhanced communication was a necessary component of all strategies and therefore decided to frame it as a broader recommendation rather than as a separate strategy itself. We recommended prioritizing the following principles related to communication and feedback:

(a) *Prioritizing interactive communication and feedback*. Workers felt that ongoing support from leadership helped them feel secure and welcome in sharing input about the food donation program without concern of recourse. Dissemination of the Champion-developed strategies may also demonstrate that workers' ideas and expertise are valued.
(b) *Developing clearer processes, spaces, opportunities, and points of contact* for workers to raise questions, share ideas and input, provide feedback, and ensure accountability, responsiveness, and follow-through. Workers noted that it would be helpful to have a specific person at the subregional level that they could communicate with about donations.
(c) *Further increasing worker access to tools and technologies* (e.g., phones, iPads, computers) to enable ongoing and timely communication and feedback about the food donation program, including options for anonymity, as well as day-to-day communications about the donation process and other work-related issues.

Workers noted that utilizing these enhanced communication principles in the context of the food donation program might also set a precedent for using similar approaches to improve other company programs and operations.

Discussion

In this project, we used a worker-centered approach to explore common barriers to food do-

nation faced by frontline grocery retail workers and describe co-created strategies to improve food donation. In response to the prioritized barriers to donation, workers recommended four strategies, including conducting new trainings; utilizing updated donation guidelines with posters and detailed handouts; strengthening connections between donation partners, workers, and stores; and running a donation incentives contest. Additionally, the Champions highlighted the need for timely, accessible, and reciprocal communication and feedback as essential to the success of all four strategies and to the food donation program generally.

At first glance, these strategies may not seem groundbreaking or surprising. For example, training workers is a widely recognized, perhaps even obvious, method for improving performance and outcomes (Elnaga & Imran, 2013). However, the strategies presented here are unique in that they were developed *by* workers, *for* workers, and in that they are based on the direct daily experience of engaging in the food donation process. We found that there were large differences in the details and emphasis of strategies currently used by corporate leadership, who may or may not have recent frontline worker experience, and those created by the Champions. This was most clearly demonstrated in the previous training and current donation guidelines, which workers found largely insufficient.

The specific strategies developed by the Champions in this study align with outcomes of previous research. De Moraes et al. (2020) outline numerous ways to reduce and/or prevent retail waste in their comprehensive review, including providing training schemes and advanced professional training and workshops on waste reduction (Strategy 1). Two research articles included in the review, Derqui et al. (2016) and Göbel et al. (2015), emphasized the need to extend these activities to employees throughout the chain of command. Additionally, the U.S. Food Waste Pact (2024) found that holding competitions within or between stores, recognizing employees for meeting food waste targets and milestones, and using monetary incentives to reward food waste reduction achievements were successful strategies to engage employees in reducing wasted food (Strategy 4).

To our knowledge, no previous research studies have focused on strengthening relationships between donation partners and workers (Strategy 3). One strategy for strengthening this relationship might be offering frontline staff paid time off to volunteer. In a survey of 120 companies in various industries, approximately 60% reported having volunteer "time off" policies, in which employees spend a set number of hours per year volunteering while still receiving their regular compensation (America's Charities, 2018). This strategy would require retailers to allocate additional resources to cover time for workers, which may be difficult for grocery retail companies, who notoriously have tight profit margins. At the same time, companies may experience benefits that justify the additional investment. For example, volunteer time off and similar employee volunteerism policies have shown to increase productivity, employee engagement, and improve hiring and retention (Rodell, 2021). Additionally, companies benefit by improving their image in the community and increasing trust and morale among employees (Cycyota et al., 2016; Gómez Santos & Fernández, 2017). The company also benefits from increased skills acquisition by employees (Gómez Santos & Fernández, 2017). Considering this evidence, providing paid time to visit donation partner sites may prove beneficial beyond improvements to the food donation program.

Next Steps for Research, Policy, and Practice

This was a formative research study conducted with the purpose of developing strategies to improve food donation; our goal was not to evaluate the strategies' effectiveness or implementation. Therefore, future studies should focus on evaluating the extent to which the strategies improve the quantity and quality of donated foods. Additionally, studies should assess the external, internal, and individual factors necessary for implementation (Damschroder et al., 2022), as well as specific implementation outcomes (Proctor et al., 2013). Although this study was conducted with one major grocery retail chain, the strategies may be applicable to other retailers. We strongly recommend that any grocery retailer interested in implementing any or all the strategies presented here maintain the

philosophical and practical commitment to centering frontline workers' input, perspectives, opinions, and repeated feedback in their process.

Prior to implementing the strategies at scale, we recommend rigorous pilot testing to assure that the strategies are appropriately adapted. For example, literature on extrinsic motivation suggests behavior often reverts once incentives are removed (Winkler-Schor & Brauer, 2024). Thus, although the workers suggested tapering the donation incentive contest after one year, it may be necessary to continue the contest to ensure long-term participation. Pilots should take place in a variety of stores and contexts (e.g., mix of high- and low-volume stores; urban, suburban, and rural stores; stores that are currently donating at various levels).

Additionally, there is a need for policy change and accompanying education regarding date labels. In the study stores, workers were required to discard foods if they were past the date label. Food date labels are not federally standardized (except for baby formula) and do not provide guidance about food safety. However, many retailers and consumers use date labels as if they were objective measures of safety and/or quality, leading to increased waste at the retail and household levels. Although most donated food can be safely eaten well past the date on its label, many retailers and consumers believe that such food is unsafe or unpalatable. This can prevent retailers from donating food in the first place and create dignity issues for recipients who may feel they are receiving low-quality food (Neff et al., 2025). Additionally, approximately a quarter of food retailers hold misplaced fears about liability related to food donation, despite federal protections under the Bill Emerson Good Samaritan Food Donation Act (Natural Resources Defense Council & Harvard Law School Food Law and Policy Clinic, 2017). Federal standardization of date labels, accompanied by education targeting retailers and consumer, would clarify which foods are safe to eat and could lead to increased food donation and reductions in wasted food.

Strengths and Limitations

The biggest strength in this study was the inclusion of workers in every step of the research process, from identifying the problems to creating the proposed solutions, ensuring the strategies are based on workers' own experiences and insights. Frontline workers bring a wealth of expertise and insight to their work, but far too often their potential is not recognized or factualized. Although Company X and other retail corporations state that they engage workers by listening to and incorporating feedback into their daily processes and new initiatives, there is still room for improvement. In our experience, there were major differences between worker-*engaged* and worker-*centered* approaches, both in terms of process and outcomes. The former can be largely symbolic and reactive, while the latter, illustrated in this study, can be highly motivating and impactful. We encourage all retailers to adopt more worker-centered processes and strategy development which, when facilitated authentically and intentionally, can result in improved ecological, financial, operational, and societal outcomes.

Additionally, the HCD process allowed the research team to learn from the expertise of frontline workers; the resulting understanding improved the rigor of the analysis of interview and observational data. The project also benefited from collecting data from numerous groups (e.g., corporate leadership, donation partners), providing a more comprehensive understanding of the strengths and weaknesses of the existing food donation program and of other issues than could be obtained from workers alone. One limitation we may have encountered in our data collection is the Hawthorne Effect, which occurs when people behave differently because they know they are being watched (Spencer & Mahtani, 2017). Although we were unable to completely mitigate this type of bias, we triangulated the results of our observations with results from our in-depth interviews across all stores and included only results that were consistent across both data collection methods.

One limitation is that the four strategies reflect insights from only the four participating stores, which previously donated little to nothing, and thus are not representative of Company X's full retail chain. Nonetheless, basing the project within such stores aligns with one best practice in HCD: to "design for the extremes," which involves creating interventions that can perform effectively in the

most challenging situations. When we design for extreme users, we assume that solving for the most challenging barriers will improve everyone's experience. Accordingly, while these strategies might be most impactful in stores with limited donations, all may benefit. Additionally, we did not assess donation barriers in other stores or companies and cannot be sure these barriers are industrywide or that the strategies created by workers in this study address the main barriers in all grocery retailers. However, a previous study of workers from various grocery retail chains found similar barriers, such as worker lack of awareness, inflexible procurement requirements, and unclear policies on waste prevention (Ceryes et al., 2021). Additionally, the U.S. Food Waste Pact (2024) conducted sector-specific interviews within their 15 signatories (including Walmart, Aramark, Ahold Delhaize) and found similar strategies for wasted food reduction, such as training workers, holding competitions, recognizing workers for meeting waste reduction targets, and providing monetary rewards.

A final limitation is that corporate leadership expressed resistance to all but one proposed strategy, with feedback centered primarily on cost. This reflects a misalignment between worker-recommended solutions and company investment priorities. Piloting these strategies would allow companies to assess their effectiveness and conduct a full cost-benefit analysis, which may reveal additional social and financial gains. For example, we hypothesize that investing time and money for workers to learn about and build connections with their store's donation partners (Strategy 3) would help build mutual trust and increase the amount of unsold food going to donation partners, which in turn, would reduce each store's waste hauling costs, in addition to benefits such as improving worker satisfaction and company reputation.

Conclusion

Grocery retailers currently donate more food than any other sector, yet they continue to discard vast amounts of high-quality food, and there remains much potential to waste less and donate more. Increasingly, states and cities have implemented laws to keep food out of landfills (US Composting Council, 2025). As policies banning organic waste expand, grocery retailers will need to increase the use of alternative solutions, such as donating, to manage surplus food. Ultimately, realizing this untapped potential will depend on the frontline workers tasked with the everyday decisions about what food can be sold, discarded, or donated, and manually separating that food for donation pickup. This project breaks new ground by not only working to identify and address the barriers faced and prioritized by frontline workers, but also by centering the workers themselves in an HCD process to create responsive strategies.

Acknowledgments

We want to recognize the Food Donation Champions who put their hearts into this project. We are also grateful to our partners at Company X for their willingness to collaborate with us on this important work. Additionally, we are grateful to the many donation partners who make the food donation process possible, and particularly to those who took the time to share their knowledge with us. Finally, we would like to thank our amazing colleagues and friends in our research network, whose ideas and support contributed to this project's convergence and benefits.

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Appendices

Appendix A. Sample of the Curriculum Outline Developed for Strategy 1: Conduct New Trainings for the Food Donation Program

Strategy 1: Conduct New Trainings for the Donation Program

About this Training Guide

In the spring and summer of 2023, the project used an -driven cohort model to explore the end-to-end process of food products entering and leaving stores in the region. Through the project, shared their experiences with and perspectives on existing practices, bright spots, and challenges in the retail setting that impact food donation and waste. The and Johns Hopkins/MICA team used this information to co-design strategies to strengthen donations.

Based on the associates' experiences, expertise, and recommendations, the Champions prioritized developing guides for all and leadership at to be retrained about the Donation Program. The program's success requires and leadership to understand program procedures and their own roles within the program, and to appropriately and consistently know which items should be sold, donated, or discarded. Success may be further strengthened based on knowledge of the program's social benefits, which the training provides. emphasized that it is important for leadership at all levels to be trained to create collective knowledge and buy-in so that they can provide guidance to those who report to them. Cross-level training will also contribute to a more positive culture of food donations within the , as everyone will share knowledge of the processes of food donation and its impact in the community.

Messages from leadership about their priorities make a difference. Store Directors prioritize what their District leaders prioritize; District leaders prioritize what their Division leaders prioritize; and Division leaders prioritize what their National leaders prioritize. If it is clear that this is a priority to all levels of leadership, then that will ultimately impact the associates in stores who making decisions about what is and is not donated.

This document provides outlines of eight training programs adapted to the needs of at all levels of (National Corporate, Division Corporate, District Corporate, Operation Specialists, Store Directors, Department Managers,). The trainings cover:

- The importance of the Food Donation program
- Donation food safety and quality
- Food donation processes (and challenges)
- Donation incentives
- Strengthening connections with Donation Partners
- Overview of roles and responsibilities, and chain of command
- Opportunity for Q/A

DRAFT — 1

Next steps for strategy: These outlines should be further developed into detailed training curricula. It will be valuable to have associates provide input on these curricula prior to piloting and implementation.

Key Principles of Food Donation Trainings

These training guides have been created by emphasizing the following key principles. The training program should prioritize:

- Strengthening the culture of donation at , including by demonstrating leadership commitment to food donation, and by building motivation and engagement
- Keeping the training program rooted in insights from store-level ' lived on-the-ground experience and expertise
- Providing the information and skills associates need to play their roles in the Program
- Including time and space for those being trained to ask questions and provide feedback.
- Combining multiple modalities and provide backup resources, to make trainings relevant, engaging and effective
- Reaching at all levels

Training Delivery

were adamant that for Department Managers and Operations Specialists, in-person, hands-on trainings would be most effective in building knowledge and engagement. At other levels, virtual training via Microsoft Teams may be sufficient. Recorded trainings could be used for refreshers. We recommend a training hierarchy (Figure 1) in which the and the would train other members of National Corporate, Division Food Safety Directors, Division The would select district-level Champions (a new role, explained below), and would train those Champions as well as District Presidents. The new Champions would train both Store Directors and Operations Specialists from each department. The Store Directors would train , while the Operations Specialists would train Department Managers.

emphasized the importance of ensuring participants remain engaged, via interactive, hands-on, and relevant information and activities, and/or by keeping each training session relatively short. Further, **training facilitators and planners need to ensure that attendees prioritize this training and minimize distractions** (e.g., requiring participants to turn on their video, closing out of email inboxes and other messaging apps, silencing phones, etc.)

Based on the importance of these trainings, we recommend they be **mandatory at all levels**, to be completed as the first step of the re-rollout. Makeup sessions may be necessary to accommodate all associates.

DRAFT — 2

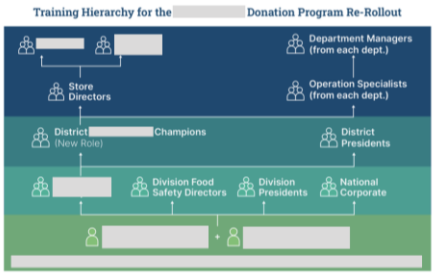

Figure 1: Training Hierarchy

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Store-Level: Department Manager Training 16
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Store-Level: Receiver Training 18
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Summary of Roles and Responsibilities, Chain of Command, Training Hierarchy 22

Note: The Division-Level training is elaborated most fully. The sections for all other trainings indicate ways to adapt that template.

DRAFT — 3

Division-Level Leadership Training

STRUCTURE

Audience: Division Presidents + Division Food Safety Directors + Division Champions
Meetings: One 60-90 min training for full group; One 30-60 minute training for Division Champions regarding additional roles
Format: Microsoft Teams meetings
Led by:

CONTENT

1. Overview of food waste, shrink, donations, and impact

- Overview of food insecurity nationally
  - Magnitude; effects on physical, mental health
- Overview of food waste nationally and in retail
  - Magnitude, including % from retail; effects on environment
- Donations, shrink, and waste at
  - Total amounts
  - Environmental/social impacts of donations
  - Financial impacts for
    - Cost to landfill and manage waste; cost differences between hauling to landfill, divert composting, and donating

2. Food Donation Program Mission and Benefits

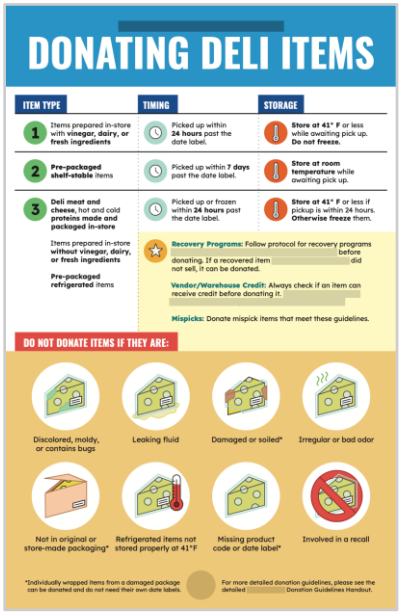
- "With all the above in mind, we created the food donation program…"
- Overview of goals
  - General goals
  - Specific goals (E.g., Every department in every store actively participates in donating; goals for frequency and amount)
- commitment to food donation; benefits of this commitment
  - Financial savings, tax benefits
  - Community goodwill -
  - Environmental goodwill
  - Addresses bans on sending organic waste to landfill in some states/localities
    - Can't forget that primary goal is sales, but when food can't be sold, donation is far better than the alternatives.
- are greatest asset to the donation program
  - Daily actions create program success
  - expertise and experience leads to real world solutions that are helpful in troubleshooting and in further increasing impacts
- Examples of existing partnerships between stores and Donation Partners
  - Include 1-2 examples of Donation Partners and their impact (with photos)

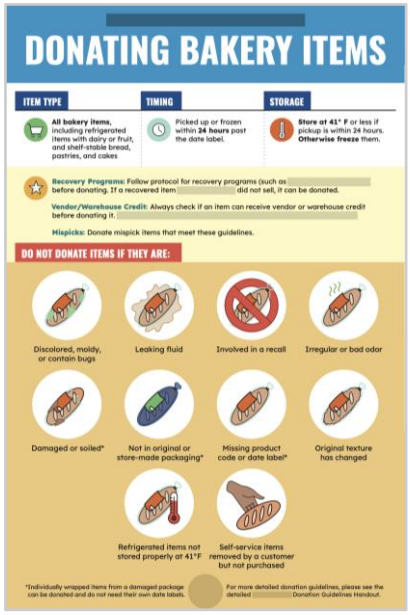
3. Donation Tracking

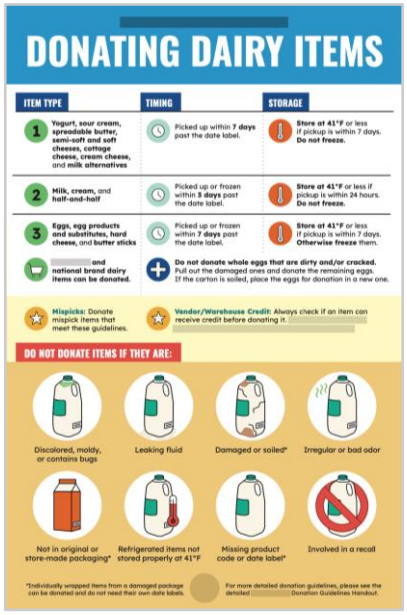
- Describe current donation data, including general trends regarding donation level by Division

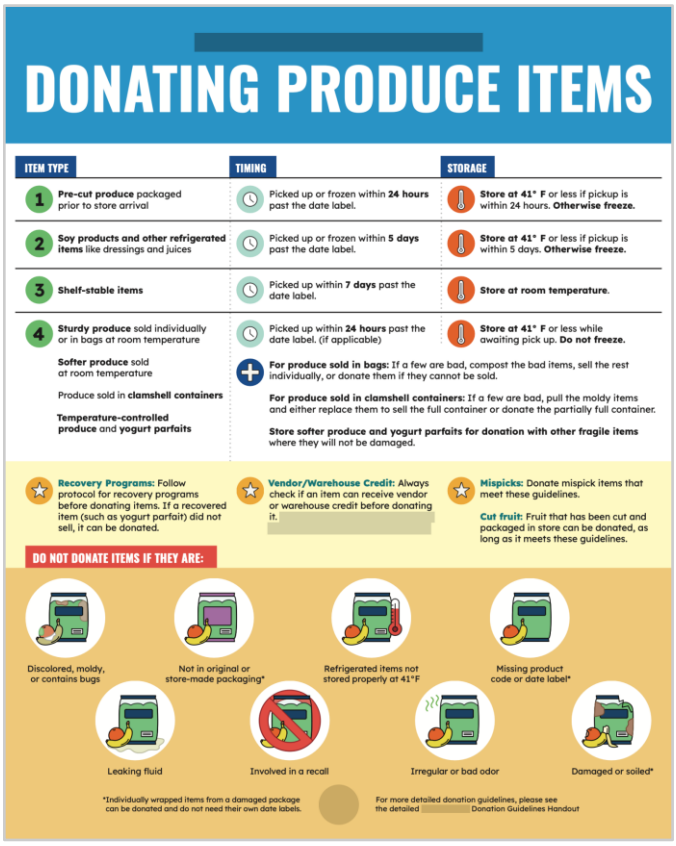
DRAFT — 4

Appendix B. Sample of the Donation Guidelines Posters Developed for Strategy 2
Posters were developed for all department in the stores.









Appendix C. Sample of the Donation Guidelines Detailed Handouts Developed for Strategy 2

Detailed Handouts were developed for every department in the store.

Donating Produce Items

Please do NOT donate items if they are:

- Moldy or contain bugs/insects
- Give off an irregular or bad odor
- Discolored
- Overly soft or mushy or have large soft or mushy spots
- Leaking fluid
- Involved in a recall
- A refrigerated item that has not been stored at 41° F or less or has been stored outside of refrigeration for more than 4 hours
- Packaging is expanded/bloated
- Packaging is damaged or soiled to where it is opened and the food is or could be compromised
  - **For products that contain a bag inside a box:** If the outer box has been damaged or opened but the bag inside is still intact, you can donate it.
  - **For products that contain individually wrapped items:** If the outer package has been opened or damaged, but the individually wrapped items are still intact, you can donate them.
- Not in their original or store-made packaging
- Usually have a product and/or date label or code but it is missing
  - **For individually packaged items that come in a larger box:** the date may be listed on the box. It is still okay to donate if individually packaged items do not have a date as long as the date is listed on the larger box.

[See next page for additional guidelines]

Donating Produce Items

Please DO donate:

Item Type	Timing, Storage, and Additional Guidelines
Sturdy produce that is sold individually and stored in bins at room temperature (Such as whole oranges, apples, bananas, lemons, limes, onions, whole melons)	Store at 41° F or less while awaiting pick up.
Sturdy produce that is sold in bags or sacks at room temperature (Such as potatoes, onions, lemons, apples)	Store at 41° F or less while awaiting pick up. If you have a sack or bag of produce and one or a few in the bag are bad, open the bag and compost the items that are bad. If the rest of the bag can be sold individually, place them out on the floor. If they cannot be sold individually, donate them.
Softer produce stored at room temperature (Such as peaches, plums, nectarines, tomatoes, berries)	Store at 41° F or less while awaiting pick up. Store in a box with other fragile items like bagged salads and put somewhere where that box will not get damaged. Be mindful that soft produce is especially prone to damage and texture changes. If an item has a soft spot, it will not be able to wait long for pick up. Depending on the item, it may need to be picked up within 24 hours after it is pulled/culled from the department floor.
Produce sold in clamshell containers (Such as cherry tomatoes, strawberries, blueberries, blackberries)	Picked up within 24 hours past the date label (if applicable). Store at 41° F or less while awaiting pick up. Store in a box with other fragile items like bagged salads and put somewhere where that box will not get damaged. If there are a few bad items within a clamshell of produce, remove the moldy items and either (a) replace them to sell the full clamshell container or (b) donate the partially full container. If the clamshell is expanded or enlarged do not donate.
Pre-cut produce that was cut and packaged prior to arriving to the store (Such as pre-cut vegetables)	Picked up within 24 hours past the date label. If donation pickup is within 24 hours, store at 41° F or less while awaiting pick up. Otherwise, if donation pickup is in more than 24 hours, freeze at 32° or less for up to one month.
Yogurt parfaits	Picked up within 24 hours past the date label. Store at 41° F or less while awaiting pick up. Do not let them sit out unrefrigerated for any length of time, even while culling/pulling other products from the floor. Store in a box with other fragile items like bagged salads and put somewhere where that box will not get damaged.
Refrigerated soy products (such as tofu, satan, tofurkey)	Picked up or frozen within 5 days past the date label. If donation pickup is within 24 hours, store at 41° F or less while awaiting pick up. Otherwise, if donation pickup is in more than 24 hours, freeze at 32° or less for up to one month.
Shelf-stable items (Such as nuts, salad toppings) and **other refrigerated items** (Such as dressings, juices)	Picked up within 7 days past the date label. Store shelf-stable items for donation pick-up at room temperature. Store refrigerated items at 41° F or less while awaiting pick up.

[See next page for additional guidelines]

Donating Produce Items

Additional Guidance

Vendor/Warehouse Credit: If an item can receive vendor/warehouse reclamation credit, make sure it does. If the credit has been received and the vendor/warehouse does not want the item and is ok with it being donated, then the item may be donated. DO NOT

Recovery Programs: If an item can be recovered into another product for sale, do that first. Examples include recovering cherry tomatoes into a vegetable tray or recovering a partially bad melon into a cut fruit bowl. If the product cannot be recovered or there is already a large stock of the recovery product, then you may donate the items.

- If the product is a recovered item but did not sell and it is still within the acceptable date range, it can be donated.

Cut fruit: Fruit that has been cut and packaged in store (such as watermelon, mixed fruit clamshells, etc.) can be donated as long as it meets the criteria above.

Mispicks: Mispick items within the acceptable date range should be donated.

Appendix D. Service Blueprint was Developed to Demonstrate the Donation Partner Immersive Training

Figure D1. First of the Three Services or Events in Strategy 3 to Strengthen Connections between Donation Partners, Workers, and Stores

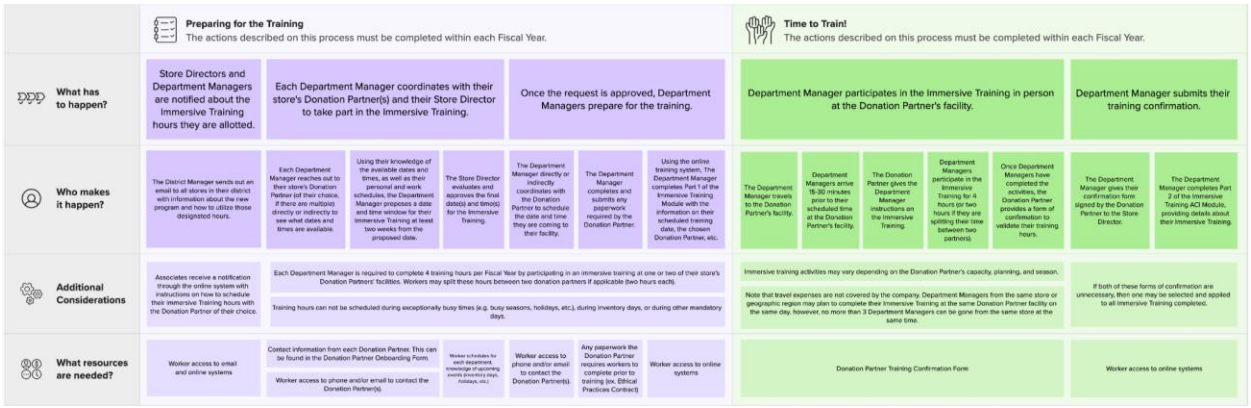


Figure D2. This Service Blueprint was Developed to Demonstrate the Donation Partner Teach-In Visits, the Second of the Three Services or Events in Strategy 3 to Strengthen Connections between Donation Partners, Workers, and Stores

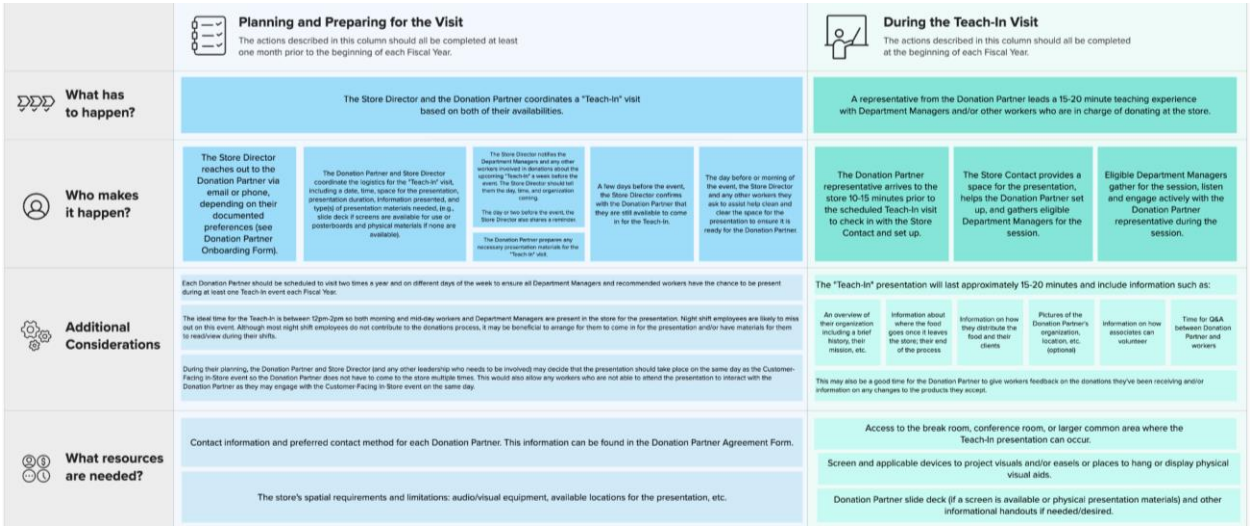


Figure D3. This Service Blueprint was Developed to Demonstrate the Donation Partner In-Store Events, the Third of the Three Services or Events in Strategy 3 to Strengthen Connections between Donation Partners, Workers, and Stores

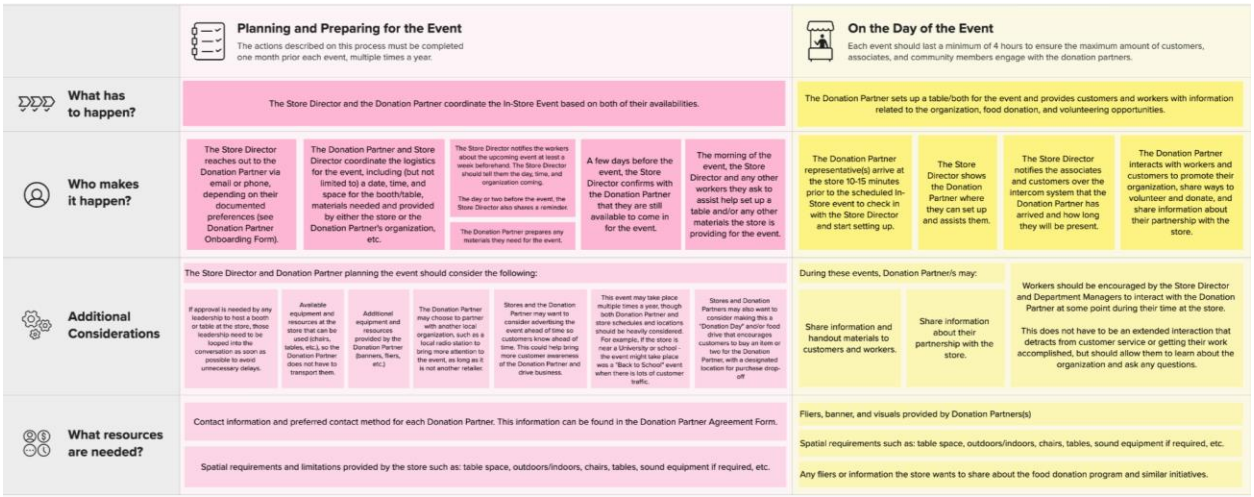
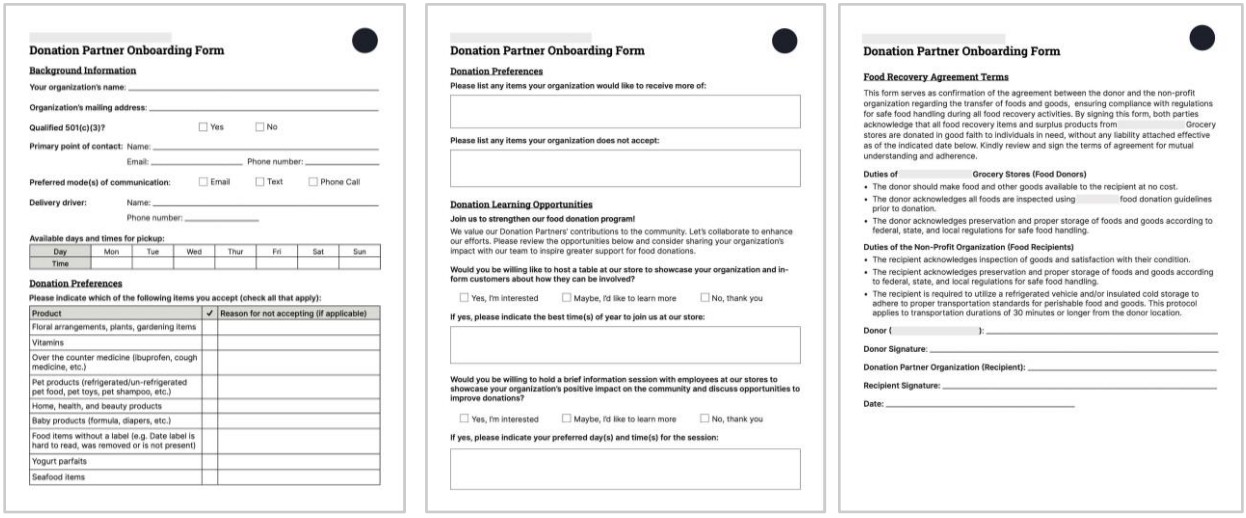


Figure D4. The Donation Partner Onboarding Form, Developed as Part of Strategy 3 to Strengthen Connections between Donation Partners, Workers, and Stores; the Form was also Designed in Black and White



Appendix E. Service Blueprints

Figure E1. This Service Blueprint was Developed to Demonstrate the 12-Week Model of the Donation Incentive Contest for Strategy 4

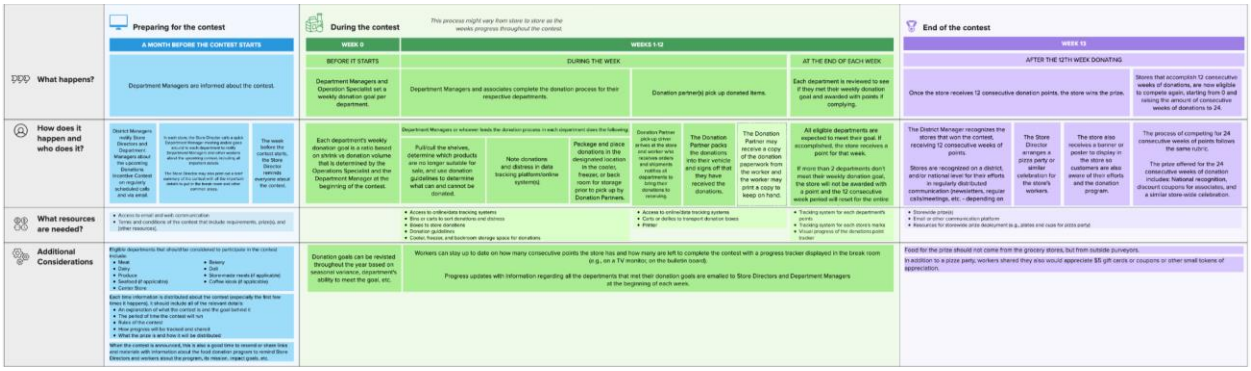
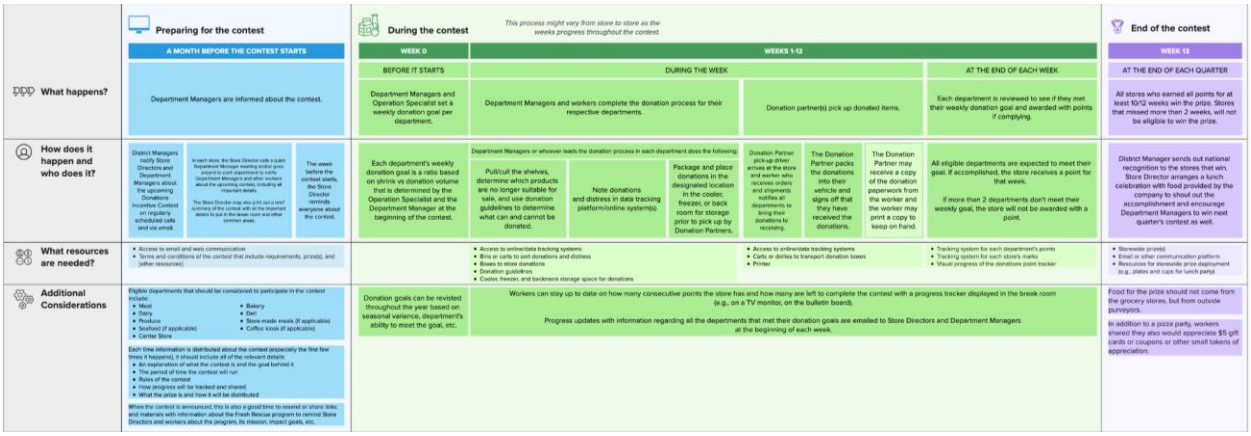


Figure E2. This Service Blueprint was Developed to Demonstrate the Quarterly Model of the Donation Incentive Contest for Strategy 4



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Future-proofing the regional foodshed: Evaluating the supply of off-season produce to feed a city

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Abstract

During the winter, in countries like Canada, there is growing reliance on fresh fruits and vegetables imported from more southerly bioregions. The transcontinental supply chains that carry these foods are vulnerable to stochastic shocks, one extreme weather event or tariff dispute away from slowing or stopping. This vulnerability raises pressing questions of national food and nutrition security. However, can countries where winter weather slows or even stops production supply their own fruits and vegetables during this season? A common assumption is that a re-localized food supply in such regions would mean a winter diet of rutabaga and

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Conflict of Interest Disclosure
None of the authors have any financial or other interests that might be construed as resulting in an actual, potential, or apparent conflict in his or her role as an author of the paper, regardless of amount or value.

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Ethical Approval and Informed Consent Disclosure
This work received ethics approval from the University of Toronto, and participants provided oral informed consent prior to participation.

Data Availability Statement
Our data is confidential as per our Research Ethics Board protocol.

potato. Thus, we investigated what regionally grown produce is available for sale during the off-season at Canada's largest wholesale food market, the Ontario Food Terminal in Toronto. We conducted an interviewer-administered questionnaire with Ontario farmers and produce dealers to assess the social and environmental conditions that produce the current winter supply and the potential for scaling up local reliance on winter produce. From our findings, we argue that a winter supply can and does exist. We find that barriers that currently limit the off-season crop supply, and opportunities to expand it, are both ecological and economic. Factors influencing supply include crop varieties, storage technologies, and market characteristics. Our findings are pertinent to regions with an interest in future-proofing their food and nutrition security at a time of geopolitical realignment.

Keywords
urban food systems, food security, food policy, nutrition security, food sovereignty, produce supply chains, wholesale

Introduction

In any major chain supermarket in Canada's largest city of Toronto—on any day, of any week, in any season—you are guaranteed to find fresh fruits and vegetables transported by ship, air, rail and road from around the world. More than half of vegetables Canadians consume (not including potatoes) and up to three-quarters of fruits are shipped to the country from distant growing regions (Bajaj, 2024; Bajaj & Ramankutty, 2023, 2025). For years, food systems scholars have warned that reliance on distant agroecosystems for food is vulnerable to stochastic shocks (Chavez-Miguel et al., 2024; Gaupp, 2020; Saccone & Vallino, 2025). Supply chains are just one ice storm or border closure away from coming to a halt. Now, rising food prices along with shifts in the modern economic order are raising pressing questions of national food security, as well as nutrition security, which is the availability and access to the foods needed to meet dietary standards (Moore et al., 2021). Can a food import-dependent country like Canada continue to rely on other countries to feed its people? In an increasingly urbanizing world, where should sprawling cities source nutritionally important foods, such as fruits and vegetables?

In some of the food systems literature, it has been argued that to be food secure, a city region must have capacity to produce food (Opitz et al., 2016; Steenkamp et al., 2021). Fruits and vegetables traditionally grown near cities are often identified as the type of crops best suited for re-localized urban and peri-urban production (MacRae et al., 2012; Nasr et al., 2011). However, the authors of this paper—a food systems scholar, a PhD candidate who is also a former organic farmer, along with a local-food system advocate and city employee working on food-related policy—have heard policymakers and the public say that it would be challenging, if not impossible, to re-localize production for a city like Toronto. One reason offered is the winter season that limits conventional field agriculture for at least six months of the year. This tension between a food system ideal of re-localized agriculture and a widely held perception of the limits posed by winter motivated our team to investigate. We undertook the first academic study of its kind, that we know of, to investigate what regionally grown produce is available for sale during the off-season at Canada's largest wholesale food market, the Ontario Food Terminal. We asked farmers who sell their produce wholesale at the Terminal, as well as dealers of regional produce, what produce they sell in the off-season. which stretches from late fall to early spring. Our goal was to understand what producers saw to be the limitations and possibilities of year-round production in support of a re-localized food system.

In this paper, we report on our findings and argue that an off-season supply can and does exist, contrary to oft-repeated assumptions. However, it is limited by both ecological and economic factors that we discuss in this paper (Agriculture and Agri-Food Canada, 2020; Unc et al., 2021). The research is pertinent to other municipalities in regions that experience winter with an interest in future-proofing their food security. Furthermore, our research informs urban approaches to food and nutrition security, as well as food sovereignty debates, at a particularly turbulent geopolitical time shaped by the climate crisis.

Different Approaches to Re-Localizing Farming Systems

In temperate bioregions, the outdoor growing season is limited by frost that kills most commercial food crop plants and renders dormant perennial fruit and nut trees. Thus, food security historically has depended on preserving and storing food. In the area where present-day Toronto is located, prior to the imposition of the settler colonial state, Indigenous nations dried cultivated foods such as squash, beans, and corn along with foods they harvested from managed wild species of plants, mammals, and fish (Riley, 2013). As colonial food systems were established as part of the plan to take over Indigenous land, historians have documented that apples and root vegetables were central to the settler diet (Dickau et al., 2021). Regional settler food economies developed with a range of foods shipped to the region (Dickau et al., 2021). Over the next century, produce supply chains became global (Elton et al., 2025). Major chain supermarkets contributed to the changes, consolidating their supply chains by sourcing directly from farms around the world to assemble a seasonless supermarket produce aisle where consumers could find the same products every day of the year (Burch et al., 2013; Reardon, 2006). During the winter in Toronto now you can find dragon fruit from the Mekong Delta sold alongside fresh mint from Morocco and asparagus from Peru. The days of subsisting through the winter on apples and root vegetables are long gone.

Scholars and social movements alike have argued that food system sustainability involves rebuilding regional food systems. Alternative food networks (AFNs) are positioned in contrast to the global industrial food system. Their short food supply chains connect producers and consumers and provide "quality" food and place-based values through certifications programs such as fair trade or organic (Renting et al., 2003; Marsden et al., 2000). Another approach, the City Region Food System (Blay-Palmer et al., 2018, 2021), sees a food system as inherently cross-jurisdictional and aims to strengthen rural-urban linkages, develop regional coherence through collaboration, and secure livelihoods of people across the rural-urban continuum through the food system. An additional concept, the territorial food system, has emerged largely in a European context. It is a regional network, providing small and midsized food businesses along the supply chains more opportunities to participate than they would in the dominant food economy (International Panel of Experts on Sustainable Food Systems, 2024; Rastoin, 2014). By leveraging the concept of territorial provenance and socially proximate relations, the territorial approach also positions itself in opposition to the agro-industrial paradigm. Its aims are to re-localize and reconnect production and consumption on the basis of environmental, social and economic sustainability (Organization for Economic Co-operation and Development, Food and Agriculture Organization of the United Nations, & UN Capital Development Fund, 2016). While these approaches make a case for a variety of food system priorities, they all emphasize the importance of regional food systems. And any kind of regional system must provide sustenance year-round.

Year-round Food and Nutritional Security

In countries that experience cold winters, there are material obstacles to a year-round supply of produce. Freezing temperatures challenge crop production in Canada (Brown & Blackburn, 1987). Nevertheless, there are ways to ensure that there is fresh produce for sale during the winter months. For example, a farm can grow large volumes of storage crops, such as pomme fruits, root vegetables, nuts, grains and pulses, to keep and sell over the winter. Farms can also extend the growing season. High- and low-tunnels are simple constructions of steel and plastic that cover and insulate field crops from frost. Some farms may heat the structures while others choose frost resistant crops, such as leafy greens like kale, that can withstand temperatures around freezing. Other indoor growing environments, such as greenhouses and mushroom facilities, provide and control all inputs that crops require indoors, such as temperature, light, and fertility.

Season extension is supported by specialized equipment and crops bred to perform optimally under different growing conditions (Ampim et al., 2022; Neri et al., 2012). These adaptations have provided ways to mitigate climate risk and improve

resource-use efficiency. However, energy costs are significant, mainly attributed to the lighting and heating systems of indoor growing environments, as are the capital costs of new technology. There is also the high risk of failure during the early period of application (Ampim et al., 2022; Kalantari et al., 2018). In the province of Quebec, the government reimburses farmers up to 40% of electricity costs. The provincial government has also invested in doubling the province's greenhouse operations while expanding rural electrical networks (Wheeler, 2023).

There are other ways to ensure year-round access to regional produce in a winter climate. Summer crops can be processed and frozen, dried, canned, fermented, or smoked. These techniques require different infrastructure, from processing facilities to storage at a commercial scale. In Canada since 2000 what has been called the local food movement has fostered interest in traditional foodways, at an individual level, in canning and root cellars where people can keep their own storage crops over the winter (Elton, 2010b; Llana, 2021; Pinchin, 2012). However, these approaches are about behavioral change as opposed to food policy or food system change, and only work for people who have space to store food. For society-wide access to regionally produced food all year round, this issue must be approached at a wider scale.

Nordic countries are taking steps to strengthen year-round production through national aid programs that respond to the significantly higher production costs of northern climate agriculture (Government of Finland, 2017). Quota and compensation programs are used to manage the wholesale prices of dairy and meats, while trade barriers and tariffs keep domestic product competitive relative to imported product (Selten, 2021; Yu & Jensbye, 2024). For instance, many Nordic countries are members of the EU's Common Agricultural Policy, which relies heavily on import tariffs and other trade barriers to protect its internal agricultural market and make non-EU goods more expensive (Jelliffe, 2025). In Canada, supply management exists for poultry, eggs, and dairy, which extends to milk products such as cheese. The produce industry is not covered by supply management. Under the iteration of the Canada-United States-Mexico Agreement (CUSMA) that was in place at the time of submission of this study, there is free trade for fruits and vegetables. Thus, Canadian-farmed produce competes with internationally grown produce.

Study Context

We conducted our research at the Ontario Food Terminal, the largest wholesale terminal in Canada and one of the largest on the continent. The Terminal was founded in 1954 by the provincial government to reduce produce waste, modernize and organize the sale of fresh fruits and vegetables, and to connect farmers to the urban market (Cavicchia et al., 2019; Elton et al., 2025). The Terminal is exclusively a wholesale market serving only businesses such as grocery retailers, food service, and institutional buyers; members of the public cannot enter to buy food. Since its founding during a period of urban change after the Second World War, the Terminal has become a wholesale hub for both regional and international produce. Relevant to our study, there are two distinct selling areas at the Terminal (Ontario Food Terminal Board, n.d.). In the main complex, wholesale businesses sell food they import from the U.S., Mexico, and around the world alongside produce they buy regionally and nationally. Outside under the parking arcade, there is a second business area, the Farmers' Market, where Ontario farmers sell their produce directly to wholesale buyers alongside dealers of Ontario produce. Our research for this paper focussed only on the Farmers' Market because it is where exclusively regional produce is supposed to be sold. The wholesale Farmers' Market is thus public food system infrastructure that operates as part of a regional food system.

Methods

Our research questions were**:** What produce is available for sale at the Terminal in the off-season? What is the capacity for scaling up winter availability? Is there interest in scaling up? What are the hurdles? We were provided with a list of farmers and food dealers who sell at the Terminal, which we checked and added to using publicly accessible data online (e.g., business names and phone numbers). This information is not currently available in

any public repository. There is no official list of farms and dealers who sell at the Terminal, nor is the exact number of farmers' market sellers known. This is in part due to the varied nature of small and midscale farming in the province, with some farms growing hundreds of acres of mixed vegetables and others operating a few acres of specialized production. We do not claim that our findings are representative of all growers and dealers at the Terminal. However, our research offers insight into many of the foods produced and sold in Southern Ontario during the winter months.

Interviewer Administered Questionnaire

We wrote our questionnaire in partnership with a grassroots network founded by Queirolo[1] that promotes public markets. We also sought input from people who work at the Terminal. Questions probed the growing and selling of produce during the off-season (See Appendix A for the full list of questions). Everyone on the contact list was phoned between January 29 and March 21, 2025. Gregory would go through the questionnaire with the participants while sitting at a computer. They would type up their answers to each question, either verbatim when brief or using shortform to record the language and phrasing of participants, as answers were not voice recorded. Interviewer-administered questionnaire sessions would last 15 minutes to one hour, with an average of roughly 30 minutes. Directly after each session, Gregory reviewed and fleshed out the notes, ensuring that participant language was captured. Subsequently, reflexive notes were written to record noteworthy ideas or reactions. Gregory conducted a total of 40 participant interviews (n = 32 farmers; n = 8 dealers) and generated two summary documents to organize and visualize the results. Answers to open-ended questions were coded inductively using NVivo 12 Pro software to summarize the range of responses. The first round of coding generated a descriptive summary of the answers that were provided to the open-ended questions. This entailed grouping very brief answers (yes and no) into the same code and for every other unique answer, then assigning a representative code to summarize and condense the response into fewer words, so that the full range of responses could be easily reviewed. This was shared with Elton, who grouped child codes into parent codes. This produced two major thematic groups: ecological barriers and enablers and economic barriers and enablers. Data were deductively coded, organizing them into these four categories. As this study was part of a larger 5-year investigation into Toronto's produce supply chains, analysis also drew on our other research into the Terminal and the larger food system. Fieldnotes from visits to many sites along the supply chains, including farms, warehouses, and a packing house, provided context for the questionnaire data.

Research Findings

Off-season Produce Availability

We define the off-season as the period between fall and early spring when few annual crops grow easily in Ontario fields. This period typically starts after Canadian Thanksgiving in October, which previous to recent climate change was around the time of the first crop-killing frosts (Ontario Government, n.d.). The farmers we interviewed described growing and/or selling 34 different types of produce during the off-season. The five crops most frequently mentioned by farmers were: cabbage (9), peppers (5), tomatoes, (5), onions (4), and winter squash (4). The only fruits mentioned were apples. The full range of farmers' responses is in Table 1.

The produce dealers we interviewed described selling 15 different types of products, including fruits, vegetables, and maple syrup. The three most frequently mentioned products the dealers have for sale after Thanksgiving were: cucumber (5), winter squash (5), and tomatoes (4). Unique to the dealers' list of items, compared to those sold directly by farmers, were wild blueberries, maple syrup, and

[1] Queirolo founded marketcityTO, an organization in Toronto that brings together the city's public markets to collaborate and strengthen the sector. It was in her capacity at marketcityTO that Queirolo began to collaborate with Elton to design the questionnaire that generated the data for this paper. Queirolo is an economic development officer at the City of Toronto, working on small businesses and public markets.

hydroponic lettuces. The full range of dealers' responses is in Table 2.

Barriers and Opportunities for Ontario Off-Season Supply

We looked for what participants considered to be the barriers they perceive that prevent them from offering an all-year-round supply of produce, or that limit their off-season supply. We also considered how participants described their interest in *increasing* what they sell in the off-season. We then categorized these answers under two themes: ecological barriers and opportunities as well as economic barriers and opportunities. We define "eco

Table 1. Products that Farmers Have for Sale After Thanksgiving at the Ontario Food Terminal

Farmer Participant ID #	Products
1	Sprouts
2	No products available after Canadian Thanksgiving
3	Beans; zucchini; squash; leeks
4	Broccoli
5	Pumpkins; winter squash
6	Arugula; cilantro; curly and flat parsley; red and gold beets with tops; carrots with tops; red and green Swiss chard; black, red and green kale; collard greens; bunched spinach; bunched methi leaf (fenugreek)
7	Mushrooms
8	Cabbage; tomatoes
9	Cabbage
10	Tomatoes; peppers
11	Potatoes; onions
12	Nappa cabbage; bok choi
13	Apples
14	Cabbage; green beans; green peppers; rutabagas
15	Specialty "exotic" mushrooms (Shiitake, Chestnut mushrooms, Black Oyster, and King Oyster)
16	Cabbage, celery root, beets, carrots, onions, parsnip, shallots, leeks, watermelon radish, turnip
17	Greenhouse tomatoes (clusters, Roma, grape, heirloom, and other varieties); greenhouse cucumber (full size and mini)
18	Cabbage; squash; pumpkins
19	Fresh harvested heirloom carrots and potatoes; winter squash
20	Roma tomatoes; green peppers
21	Grapes; Bosc pears
22	Flowers
23	Cabbage
24	Apples (> 20 varieties)
25	Greenhouse cucumbers; greenhouse tomatoes; greenhouse peppers
26	Carrots (orange, red, and mixed); beets (red, gold, candy); parsnip; onion; turnip; parsley root; sunchokes
27	Cabbage
28	Hydroponic greenhouse bell peppers (red, yellow, orange); hot peppers; eggplant (purple, white, Sicilian and striped)
29	Oyster and shiitake mushrooms
30	No products available after Canadian Thanksgiving
31	Potatoes (17 varieties)
32	Cabbage (red, green, savoy)

logical" following the Oxford English Dictionary (2008), encompassing factors such as materiality of fresh produce, including the amount of time one can store a food before it starts to rot, differences in crop varieties that enable or impede long-term storage, and also seasonal conditions such as temperature and climate. We use the term "economic factors" to describe the business and monetary factors that impact sales. For example, the characteristics of a customer base, the marketplace itself including competition, and the availability of capital to invest in technology such as greenhouses. A summary of the barriers and enablers to off-season crop production and sales in Ontario that farmers and dealers discussed with us is in Table 3.

Ecological Barriers

The primary ecological barrier that limits Ontario off-season produce production and sales is the winter. Many participants described the colder seasons as an enduring barrier to local food production and sales. In the words of one vegetable farmer: "All product is grown by directly seeding into the soil. So it's limited by the seasons." Dealers also regarded importing fresh produce over the colder months as necessary because, as one said, "we can't grow everything year-round here." However, storage and forms of winter production were said to be possible. We found that off-season supply is determined by crop variety, the amount of food an individual farm can produce, and the nature of the season itself as a period of dormancy.

Crop Variety

The variety that a farmer chooses determines whether it can be stored, and there is an enormous array of possibilities. For example, there are hundreds of varieties of carrots to choose from, including seeds developed by multinational seed companies such as Bayer Ltd. and ones produced by smaller companies such as Ontario-based William Dam Seeds. There are also heirloom or heritage seed varieties, gene lines for vegetables grown outside of the commercial seed industry (Dwivedi et al., 2019). The farmers we spoke to explained that there are trade-offs in the seed selection process relevant to our research. For example, a farmer can choose either to plant a carrot variety that has a thick skin, conducive to storage, or a thin-skinned variety that is sold within days of harvest, bunched with its green leaves attached, and regarded in the market as having premium quality and flavour. The same trade-off applies to bunched beets. The value of the bunched carrot or beet sold with its green tops appears to outweigh the value of growing a variety that stores better. A vegetable farmer stated: "Because we are fresh market producers, the crops we grow are varieties that do not keep and are not meant to be stored…So we sell products within days of being harvested, for the best quality and flavor." Thus, whether a particular crop is suitable for storage is determined as early as seed selection. We assume that this determination also has repercussions for farm income, since perceived higher quality and flavour could in theory attract a higher price.

Table 2. Products that Dealers Have for Sale After Canadian Thanksgiving at the Ontario Food Terminal

Dealer Participant ID #	Products
1	Cucumbers (seedless and mini); tomatoes (full size and cherry)
2	Cucumbers, tomatoes, and some peppers
3	Wild blueberries; maple syrup
4	Hydroponic microgreens; hydroponic Boston head lettuce; squash; beets; carrots
5	Cucumber; colored bell peppers; pears; tomatoes
6	Apples
7	Cucumbers; lettuces; squash
8	Carrots (orange and red); onions (yellow and red); shallots; potatoes; cabbage; beets; winter squash (butternut, acorn, spaghetti); apples

Participants noted that some varieties hold their quality longer in storage than others. With the right conditions, some kinds of vegetables and fruits, such as apples and cabbage, have the capacity to be stored until the following year, when the next crop is grown and harvested. We visited an apple packing facility where apples are stored for more than six months. The multimillion-dollar facility keeps the apples under no oxygen conditions and yields a high-quality product even in the spring. However not all crops can be stored this long, regardless of variety. Participants reported that pumpkins only hold until October or November while some winter squashes can generally hold until February or March. We note that none of our participants described technology used to store squash that was as investment-intensive as apple storage.

Limits to Production

Farmers discussed how there is a limit to how much one farm can produce in the summer to store while also producing for the fresh market. Some described an overlap between the current and the previous year's harvests, such as with cabbage. However, most storage crops, such as potato, onion, squash, and leek ran out by mid-winter. An apple dealer said that some varieties may store as long as 12 months, if the supply doesn't run out or diminish in quality: "I'm always up against quality

Table 3. Summary of the Barriers and Opportunities to Off-Season Crop Production and Sales in Ontario Cited by Farmers and Dealers

	Barriers	Opportunities
Ecological	*Crop Variety* • Choosing crops and varietals that cannot be stored without rotting. *Limits to Production* • Running out of supply of product before end of season. • Different knowledge and equipment requirements for field-growing vs. greenhouse-growing. *Winter as Dormancy* • Traditionally a time of slower pace for plants and farmers in field crop agriculture.	*Winter Production and Best Practices* • Choosing crops and varietals that store well over the winter. • Continued plant breeding for optimizing winter sale period. • Access to best practice guidelines for crop production, harvest, and post-harvest handling of winter crops. *Technology & Equipment* • Access to advanced cold storage technology (e.g., atmosphere-controlled). • Use of season-extension growing equipment (e.g., high and low tunnels). • Growing crops entirely indoors.
Economic	*Business Models and Relationships* • Planning farm sales for spring, summer, and fall only. • Planning an operation shut-down phase during winter months. *Market Competition* • Domestic competition on volume. • International competition on price. • Customer demand for a wide variety of food. • Major chain supermarket dominance in buyer-seller relationships. • Reduction in small/medium-scale packing facilities. *Financial Constraints* • Prohibitive cost of expanding into winter greenhouse-growing infrastructure. • Energy costs of light and heat required for winter production.	*Demand and Markets* • Increasing domestic demand for Ontario-grown product during the off-season. • Targeting specific sales markets with particular corresponding crops (e.g., the "late potato market"). • Shifting to different buyers across the season (e.g., farmers' markets, then retail stores and restaurants). • Maintaining sales relationships with multiple buyers at once. *Wide Variety of Buyers* • Selling to a wide variety of buyers (e.g., restaurants, food processors, packing houses, wholesalers, food service suppliers, small grocery stores and large grocery chains).

and supply." Season extension can be restricted by lack of know-how. In a region such as Ontario, where fresh produce has been imported for generations, there has been little impetus to develop season extension programs. Participants emphasized the difference between farming outdoors in fields versus farming in highly controlled environments like greenhouses. They pointed out the different expertise, practices, and resources required. It would not be possible for a farmer to casually add a winter greenhouse to a field-growing operation, for example. A farmer described how they once attempted to extend the zucchini season and grow it in a greenhouse. It was only after their crop failed entirely that they realized the type of plastic they used to cover the plants had blocked the bees from pollinating them.

Winter is a Period of Dormancy

The materiality of the winter season is a challenge for farmers. The colder months have traditionally been a period when the pace of work slows down. The days are shorter because the sun sets early at this latitude, and plants become dormant. Some farmers are even able to take a holiday. During the more active months of the year, farmers often work long hours, waking before dawn to ensure their produce arrives at the Terminal in time for the first buyers. The sun does not set until late in the evening, and some farmers described having to work in the twilight periods due to increasingly severe heat conditions for field workers. Throughout the growing season, farmers who sell at the Terminal often oversee cultivation of hundreds of acres, working with a range of people in the sector, including crews of highly skilled guest agricultural workers. They must coordinate their planting schedule with the demands of the market and their customer base, as well as contend with the many uncertainties presented by the weather and climate. Like everyone else, they need a break. Some farmers told us they valued the downtime they associate with winter as an offseason, as a way of balancing out the heavy day-to-day workloads of farming from spring to fall; as one farmer said:

> We push it during the growing season, working 80–90 hrs per week, so we can take down time during the off season. However, because we start growing seedlings for the field in February, we're only really off about two months of the year.

These annual rhythms, however, are distinct from year-round indoor operations, such as greenhouses and mushroom facilities, where work cycles are more disconnected from the seasons.

Despite these ecological barriers, the data reveal that it was not the length of the growing season, nor limits to storage that constrain year-round access to some regionally grown produce that necessarily limits the food system. Still, winter is winter.

Economic Barriers

The economic barriers that farmers and dealers discussed with us involve business models, market competition, and financial constraints.

Business Models

Whether a farm has produce that it can sell in the winter is determined in part by how they plan sales. Participants identified two models of farm sales: "pick-and-pack" farms grow produce meant to be sold immediately after harvest, and "pick-and-store" farms grow crops suitable for storing and selling over a longer period. If a pick-and-pack farm were to have produce available for sale in December, it would mean their sales had been poor. Then there are the production systems that can produce year-round: greenhouses, mushroom farms, and sprout operations. However, some large-scale greenhouses noted that they could continue to produce and sell their products into the winter months, but doing so would delay the next season's production, as the months of November to March are spent cleaning their facilities and growing new plants for the upcoming season. Each of these economic models sets a farm up for either selling into an off-season market, or not.

Market Competition

Farmers offered economic reasons for choosing the pick-and-pack model over pick-and-store: selling in the off-season is not necessarily lucrative. Competition from domestic and international growers were economic barriers that limit profita-

bility of off-season sales. A farmer said they did not grow crops meant for storage because other farms nearby were doing so. Another shared that they only grow enough winter squash to store and sell for four weeks after harvest, even though they could grow more and could store it for much longer, because squash grown in Mexico is sold in Ontario, starting four weeks after the local harvest, for the duration of the off-season at a significantly lower price. Another farmer described how they grow a variety of red carrot that is highly valued by the South Asian market in Ontario. But at the time in the season when the same product is imported from overseas, Ontario farms can no longer sell theirs because the imports undercut them so steeply on price. The prices that farmers obtain for crops were also a barrier to winter production. In the case of a "pick-and-pack" farm model, one farmer described that the premium prices they are able to fetch in the fresh product market generated sufficient profit during the growing season to last their family across the whole year.

Dealers also spoke to us about the limited variety of Ontario products available during the winter months that reduces the consumer appeal of a strictly local diet. One dealer said, "We can produce cukes [cucumbers] all year round, but people want more options." As a result, wholesale dealers—even those who specialize in local products—may purchase imported products during the winter months to keep their businesses going. This particular dealer's observation speaks to the ways that food choices and habits are imbricated in these questions. Why would you want to eat greenhouse cucumbers all year round if you can access a wider variety of fruits and vegetables from all around the world regardless of season?

The market factors that influence what is available for sale in the off-season are not only global. The major chain supermarkets have transformed the produce industry by requiring suppliers to conform to their company standards (Burch et al., 2013; Wilmers, 2018). Among our respondents, farmers in particular described the influence of the major chain supermarkets on their business opportunities. One apple grower described how he occasionally sells to a packer that supplies one of the large grocery chains. Packing facilities are intermediary businesses that take raw bulk product (such as loose apples in large wooden crates) and wash, sort, and package them for retail sale. He told us that selling to a packer has become harder for small and medium-size growers because the chains will only purchase large volumes above what he can produce. He said that smaller packing houses have also closed. He described what he saw as work created by the major grocery chains and downloaded onto farmers: "The large chains can also stipulate what size fruit they want [usually only a medium size], which means you have to find other places to sell the other sizes." He expressed shock at the high prices of apples at their stores: "I can't believe what they charge." Thus the influence of the major chain supermarkets on the regional food system, that operates in tandem to the global supply chains, contributes to constraining winter supply from small to mid-scale Ontario farms.

Financial Constraints

To boost supply, growers can produce indoors or extend production into the shoulder season. When asked whether they would be interested in winter production, many farmers responded that costs were prohibitive. For those who do not already have necessary facilities, they said that building a greenhouse is too expensive. "Those already in the (winter greenhouse) game can expand, but to start into it costs about a million per acre," said one vegetable farmer. Another vegetable farmer said, "We don't have greenhouses, nor the capital to invest in them (but) if someone gave them to us, or gave us access to one, we would use it!" Additionally, because of the reduced sunlight and cold temperatures during Ontario winters, growing during these months generally requires significant light and heat supplementation. Several farmers spoke about the associated energy costs: "The limiting factor is energy," said a fruit and vegetable farmer. They pointed out that when the price of supplemental energy was added to the cost of production, the sale price would not be competitive against global market pricing.

Ecological Opportunities

The facts of winter at a northerly latitude—cold temperatures, snow, plant dormancy, plant cells

that rupture when frozen—underlie the ecological barriers we have identified in our data. Nevertheless, we sought to consider details offered by participants that could be framed as enablers, or opportunities, for boosting off-season produce supply. These include crop varieties and appropriate technology and equipment.

Crop Varieties for Storing

To produce a good product to sell in the off-season requires a farmer to consider not only storage but also the flavour and quality of their product at the time of sale, which are determined in large part by the kind of carrot, cabbage or apple chosen to plant. Over centuries of plant breeding, thousands of different varieties of food plants have been developed to improve or change qualities including taste, texture, storage, and pest and drought resistance, among innumerable other aspects (Kingsbury, 2009). Some breeding has involved genetic modification, but the vast majority of plant breeding involves less invasive methods, such as hybridization. Over the last several decades, large seed companies that develop different seed lines have bought up smaller companies, leading to a consolidated marketplace (Howard, 2015). This means fewer varieties on the market for farmers to purchase (Howard, 2020). However, smaller companies do remain that specialize in older seed lines, often called heritage or heirloom crops.

Farmers carefully choose crop varieties because different plants have different qualities. Farmers spoke about the importance of choosing varieties with good storage capacity; for example, certain cabbage and potato varieties are meant for longer storage because they peak in flavor and quality for the winter market. Farmers highlighted the need for plant breeders to develop new varieties to improve storage crops. But the variety was not the only important characteristic to consider. To maintain and extend shelf life, farmers and dealers also stressed the importance of good farming practices that produce high-quality crops in the first place. Mishandling crops leads to bruising and nicking, which can accelerate the natural breakdown process. They emphasized that coolers can only preserve and slow down the degradation of fresh produce. "A cooler is a cooler, not a hospital," said an apple dealer.

Technology and Equipment

Major advances in cold storage technology are another enabler reported by farmers and dealers for winter crop storage. Historically, coolers were constructed underground or in barns, and were made from wood. However, current practices can involve 50,000-sq ft insulated rooms with R-values of 50 or more, equipped with ventilation systems that almost entirely remove the oxygen from the air inside and clean the remaining atmosphere with ethylene filters. Several participants described these atmosphere-controlled systems as dramatically changing their capacity to store their crop, often for months longer than previously. The technology also preserves quality, preventing "shrinkage" compared to wood-built coolers. Preservatives added to produce at the washing and packing stage, such as the SmartFresh™ treatment often used on apples (AgroFresh, 2026), were noted as vital to long-term preservation.

Other equipment was noted as important for extending harvest both earlier and later in the season, such as low tunnels built over rows of field-grown crops and blankets to insulate against minor frosts. Alternatively, some crops can be grown entirely indoors, in highly controlled environments, such as sprouts, mushrooms, and a number of fruits and vegetables, such as strawberries, cucumber, and tomatoes. Due to the number of variables that need to be precisely taken into account for optimal productivity, knowledge of growing methods is vital to widespread success. This can differ from crop to crop. For instance, one farmer shared that tomato greenhouse growing methods have become more established, such as lighting levels, fertilizers, and seed varieties, while by contrast, greenhouse pepper growing methods are much less developed, with farmers still using trial and error to learn and establish best practices under expensive overhead and operating costs.

Economic Opportunities

The economic enablers that participants shared with us involve market demand and diversity of buyers.

Market Demand

One participant noted a steady increase in demand for Ontario products during the fall and early winter season over the last five years, and consumer interest in buying local produce rose in general during the COVID-19 pandemic (Elton et al., 2023) . Participants reported that this trend is continuing. A farmer who grows melons, sweet corn, and peppers that they sell alongside produce from other Ontario farms, along with a broker at the Terminal, remarked that they had increased their production in response to year-over-year increases in demand. Participants further identified what they saw as a need to encourage and expand domestic demand for Canadian produce to reduce the need to export to the U.S., some expressing concerns about selling due to on-going corporate concentration in grocery retail.

Farmers also noted the importance of being attuned to specific consumer market demands through retail channels. Produce farmers spoke about designing their farm production to align with specific times of the year. While being first to market with a given crop is often rewarded with a premium price and guaranteed sales, a farmer who grows a variety of vegetables described timing their growing schedule to produce peak volumes for the end of the growing season in early fall. He was "targeting the late market for Roma tomatoes and green peppers" for when those crops are often purchased by the bushel for home canning. Similarly, we heard from a potato farmer who strategically selected certain potato varieties for winter sales. Targeting different kinds of customers across the seasons was also noted, such as shifting from farmers markets during the summer and fall to retail stores and restaurants over the winter.

Both farmer and dealer participants described how they were dependent on several different buyers, including during the winter. Farm businesses noted that they needed to sell to different grocers, large and small. Some relied on small independent grocers while others sold to some or all the major supermarket chains. Some farmers sold directly to the public at year-round farmers markets or through their own on-farm stores. One dealer noted that while they sell product at the Terminal, they also broker sales to the major supermarket chains. These stores run growing programs for farmers, determining terms of production from start to finish, including price. Working for the chains, they said, led to fewer price fluctuations. Emphasizing the appeal of guaranteed sales, the dealer said, "By the time you're putting a seed in the ground, you've invested millions." Several farmers also sold wholesale in the U.S., one explaining that he sells 70% of their cabbage, green beans, green peppers, and rutabagas in the U.S. to generate sufficient income: "Ontario's capacity for production way exceeds the local demand. This is why exporting is vital to farming viability."

Diversity of Buyers

Toronto is one of the largest food and beverage manufacturing clusters in Canada and the U.S. (Waterloo EDC, 2023) where there are many potential buyers of produce. Participants reported selling to major food companies as well as to restaurants. One participant described selling potatoes to a potato chip company that is a subsidiary of a multinational food and beverage corporation. These sales were organized outside of the Terminal. Other food processors purchase produce at the Terminal, including companies that make ready-to-eat bagged salads. A farmer who specializes in Asian greens sells to a Chinese community wholesaler that supplies a Chinese-Canadian restaurant chain. Another participant described selling 420,000 lbs of potatoes a week to a fast-casual Canadian chain restaurant. Dealers shared that they also sell their product directly to food service suppliers, including large American multinational corporations that sell, market, and distribute food products to restaurants, healthcare, educational, and sports facilities. Business flowing through the Terminal also includes sending produce to packing houses that size, clean, sort, and package produce wholesale. In the context of selling to these major buyers, farmer and dealer participants told us that the Terminal was crucial to profitability. One farmer described that while they primarily sell to the major supermarket chains outside the Terminal, the institution "takes the monopoly edge off" by providing them with an alternate sales avenue, should they

not wish to accept the offer being made by the supermarket chain. This variety of buyers supports the produce industry's profitability.

Discussion and Policy Recommendations

From these data, we conclude that there are capacity and interest among produce farmers and dealers at the Terminal to expand off-season stock, with potential to improve winter production and storage. Participants have noticed that there is an increase in interest in Ontario-grown produce among consumers. Furthermore, the political climate is also favorable, with an increase in nationalism and consumers' principled move away from American products since the U.S. president began threatening to annex Canada. In June 2026, the federal government funded a National Food Security Strategy that includes boosting regional food systems. The ecological barriers to production, such as cold weather and limited seed varieties, can be circumvented with technologies such as storage-ready and winter-hardy seed varieties and greenhouses, hoop houses, and tunnels to extend the growing season. As government policy would enable these changes, our findings lead to the following policy recommendations, relevant to many jurisdictions, which are summarized in Table 4.

Infrastructure

It is expensive to invest in off-season production and storage. Participants told us that the burden of investing in off-season production is too high for small to mid-scale businesses. Similarly, effective long-term storage facilities are costly, as exemplified by the multimillion-dollar apple storage facility we visited during the study. When the Ontario Food Terminal was being planned by the provincial government after the Second World War, it was recognized that food system infrastructure was too costly for the producers themselves to support (Elton et al., 2025). It was in the public good for the government to use its resources to support founding the public facility. As participants noted, a secure and consistent off-season supply of regionally grown food could be supported by public investments such as grants and interest-free loans for small and mid-scale operations for scaling up off-season vegetable production and farm extension for winter production, as well as for seed breeding, community-based storage facilities, as well as other supports for processing and public wholesale food terminals such as the Ontario Food Terminal. Food system infrastructure such as packing houses, as a farmer explained to us, needs to serve not just the major players but also small and midscale growers. Despite farmers selling their produce directly to major chain supermarkets in Canada as well as to American customers, they relied on the public infrastructure of the Ontario Food Terminal. This emphasizes the important role that government can play along supply chains.

Market Factors

Global produce supply chains ensure a steady access to fresh fruits and vegetables in the winter, often at prices that are less than those of the same products grown locally. Squash from Mexico and apples from Washington State are two products that farmers and dealers described as being undercut in price by imports. In some instances,

Table 4. Policy Recommendations

Infrastructure	Governments can support off-season production by reducing barriers through grants and interest-free loans for scaling up, and investing in agricultural extension for winter production as well as seed breeding.
	Governments can support small and midscale packing, processing, and storage in public facilities close to farms, and invest in public wholesale food terminals to facilitate farmer participation in the food economy.
Market Factors	Further study of how global price competition threatens to reduce agricultural capacity in Canada is needed.
	Food policy must balance current food security with future food security so that maintaining affordability today does not compromise affordability and accessibility tomorrow.

the lower prices are the result of lower production costs in the country of origin. Squash, for example, is grown in Mexico where the wages are lower than in Ontario. A free-market logic would claim that these economic differences mean that it is rational for Ontario to import squash in the winter—the Mexican squash outcompetes the Ontario squash and therefore the market is working to keep prices low for consumers. However, as has been argued (Coase, 1960; Skolrud et al., 2020), this equation does not factor into the sale price externalities such as the emission costs of trucking the squash from Mexico (Li et al., 2022). It does not consider the fact that there are regions of Mexico where there is not enough water for the people who live there, let alone enough to irrigate export crops (Hartman et al., 2021). Low food costs in Toronto do afford food security to people with low incomes in this city. However, a focus on price above all costs is also a threat to food security. When farmers have been unable to compete on prices with imported food, they have pulled out of the competition. A farmer we spoke with said that he does not grow more squash to store over the winter because of the influx of imported squash later in the season. This withdrawal threatens to reduce agricultural capacity in Canada, which has already taken place in Ontario with two crops: apples and garlic. In 2000, 4,500 acres of garlic were grown, but farmers stopped producing it when low-cost imported garlic arrived on the market; by 2002, there were only 300 acres of garlic grown in the province (Elton, 2010a). (The province's apple industry experienced a similar trajectory (Elton, 2007)). While varying political and economic perspectives will interpret these facts differently, what we wish to highlight is that there is more at stake than just the price of food. Policymakers need to balance current food security with future food security, so that maintaining affordability today does not compromise affordability and accessibility tomorrow.

Conclusion

As we have explored in this paper, a questionnaire administered to regional farmers and dealers at the Ontario Food Terminal found that contrary to commonly held assumptions, locally grown produce is available for sale in the off-season. Furthermore, participants reported an interest in scaling up both storage and off-season production. However, what is available for sale, and efforts to scale up, are limited by both ecological and economic factors. Temperatures below freezing and low sunlight during the winter inhibit agriculture. To store products grown in the summer over the off-season, farmers require specific crop varieties. However, these varieties must compete for growing space with ones selected for fresh sales that fetch profit at market. Ontario products then must compete with often lower-priced imports during the off-season, which is a further disincentive. At the same time, advances in storage technology may facilitate better storage of crops, and therefore provide greater and longer availability of Ontario produce over the off-season. However, this kind of season extension requires financial investments. Finally, participants reported growing interest in Canadian produce from customers who want to "buy local," while also contending with competition from global actors and challenges producing and selling in a grocery sector dominated by main chain supermarkets. As such, these research findings speak to food sovereignty debates, at a time when international trade regimes are experiencing rapid changes. With meaningful investment in building regional and sustainable agricultural capacity, this paper identifies an opportunity to shift food import dependency in the name of protecting food sovereignty and nutritional security.

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Appendix A

Farmer Survey Questions

1. Are your farm products sold through the Ontario Food Terminal?
   - □ If yes, the survey continues
   - □ If no: Thank you for your interest in our survey. We are surveying Ontario farmers and dealers who sell through the Ontario Food Terminal.
2. How do your farm products move through the Ontario Food Terminal? Choose any or all that apply.
   - a. My farm sells through the farmers' market at the OFT.
   - b. My farm sells to a wholesale tenant at the OFT.
   - c. My farm sells to a dealer who sells my farm products at the OFT
   - d. A combination of above (please describe below)
   - e. Other:
   - f. (open-ended response space)
3. At what times of year do you sell your farm products at the OFT? Choose any or all that apply.
   - a. May-June
   - b. July-October
   - c. November-February
   - d. March-April
4. At what time of year do you sell the highest quantities of your product?
   - a. May-June
   - b. July-October
   - c. November-February
   - d. March-April
   - e. I sell more or less the same amount of farm products all year round
5. a) What farm products do you sell through the Ontario Food Terminal? Choose any or all that apply.
   - a. Vegetables — please list below
   - b. Fruit — please list below
   - c. Eggs
   - d. Firewood
   - e. Honey
   - f. Maple syrup
   - g. Other – please list below
   - h. (open-ended response space)

5. b) Please describe/list the farm products you sell through the Ontario Food Terminal.
   (Open-ended response space)
6. Which of those products do you have available for sale after Thanksgiving in October? Please list them below. (For example, carrots, squash, greenhouse peppers…)
   (Open-ended response space)
7. For the products you cannot produce in the winter, how do you store them in the off-season (for example, on-farm cooler, root cellar, off-farm warehouse, dealer's warehouse, etc.)?
   (Open-ended response space)

8. How long can you store your farm products after Thanksgiving and into the off-season? Please describe which products and how long you can store them for. For example, you might grow leeks that can be harvested until the first heavy frost and then store
   (Open-ended response space)
9. (a) Can you produce any of your products all year round?
   - □ Yes
   - □ No
   - □ Other (open-ended response space)
9. b) If Yes: Please describe what you produce all year round and where you do this. If No: please explain why you cannot produce your products all year round.
   (Open-ended response space)
9. c) Have you noticed any changes over the years that make possible to sell some products later in the season? such as climate changes, increasing access to equipment or technology (hoop houses, greenhouse heating, storage facilities), labour programs, or new plant varietals, for example?
   (Open-ended response space)
10. a) What volume of products do you continue to have available for sale after Thanksgiving, whether or not you are storing them or continuing to produce them? Please estimate a quantity in pounds, kilos, or bushels.
   (Open-ended response space)
10. b) What percentage does this represent out of your whole year's crop total?
   (Open-ended response space)
11. How do you grow your products? Choose any or all that apply.
   a. Open fields
   b. Hoop house
   c. Greenhouse
   d. Mushroom facility
   e. Other, please explain below
   f. Other (open-ended response space)
12. Is there any other place you sell your products in the winter month or off-season, aside from the Terminal?
   (Open-ended response space)
13. Are you interested in selling more farm products in the off-season?
   - □ Yes
   - □ No
   - □ Other (open-ended response space)
14. What is the name of your farm/business?
   (Open-ended response space)
15. How many acres do you grow produce on?
   (Open-ended response space)
16. How long have you been growing produce?
   (Open-ended response space)
17. Is yours a family business? If yes, how so?
   (Open-ended response space)
19. Where is your farm? Do you know the postal code for the land where you grow?
   (Open-ended response space)

20. Do you have plans to retire or leave farming in the near future? If so, when?
    (Open-ended response space)
21. How sure are you about your retirement plans? (Certain? Possible? Unsure?)
    - □ Certain
    - □ Possible
    - □ Unsure
    - □ Other (open-ended response space)
22. Thank you very much for participating in our survey! We are very grateful for the time and effort you spent answering our questions. Is there anything else you would like to mention that we haven't discussed yet about the OFT and its role in your business? Or anything else you would like to add?
    (Open-ended response space)

Dealers Survey Questions

1. Do you sell products from Ontario farms at the Ontario Food Terminal?
    - □ If yes, the survey continues
    - □ If no: Thank you for your interest in our survey. We are surveying Ontario farmers and dealers who sell through the Ontario Food Terminal.
2. How do you use the Terminal to do business? Choose any or all that apply.
    - □ I have a stand at the OFT farmers' market
    - □ I am a warehouse tenant
    - □ I don't show up in person at the OFT but I sell through the Terminal networks
    - □ Other - please describe below
    - □ (open-ended response space)
3. At what times of year do you sell Ontario produce at the OFT? Choose any or all that apply.
    a. May-June
    b. July-October
    c. November-February
    d. March-April
4. At what time of year do you sell the highest quantities of Ontario produce?
    a. May-June
    b. July-October
    c. November-February
    d. March-April
    e. I sell more or less the same amount of farm products all year round
    f. Other – please explain below
    g. (open-ended response space)
5. a) What Ontario farm products do you sell through the Ontario Food Terminal? Choose any or all that apply.
    a. Vegetables — please list below
    b. Fruit — please list below
    c. Eggs
    d. Firewood
    e. Honey
    f. Maple syrup
    g. Other – please list below

h. (open-ended response space)

5. b) Please describe/list the Ontario farm products you sell through the Ontario Food Terminal.
   (Open-ended response space)
6. Which of those products do you have available for sale after Thanksgiving in October? Please list them below. (For example, carrots, squash, greenhouse peppers…)
   (Open-ended response space)
7. a) Are there Ontario produce items that you sell all year round?
   - □ Yes
   - □ No

7. b) If Yes: What are they? Where do you sell these items? (Only through OFT or elsewhere too?) If No: Why? (e.g., limited growing season; storage constraints; too much competition from elsewhere to justify growing or storing the crops, etc.)
   (Open-ended response space)
7. c) Have you noticed any changes over the years that make possible to sell some products later in the season? Such as climate changes, increasing access to equipment or technology (hoop houses, greenhouse heating, storage facilities), labour programs or new plant varietals, for example?
   (Open-ended response space)
8. How are the Ontario products grown that you sell? Choose any or all that apply.
   - □ Open fields
   - □ Hoop house
   - □ Greenhouse
   - □ Mushroom facility
   - □ Other - please explain below
   - □ Open-ended response space

9. Are you interested in selling more farm products in the off-season?
   - □ Yes
   - □ No
   - □ Other (open-ended response space)

10. Is there any other place you sell your products in the winter month or off-season?
    (Open-ended response space)
11. Can you estimate how many farms you buy from?
    (Open-ended response space)
12. Where are these farms? What counties?
    (Open-ended response space)
13. How do you get the food from these farms? Do you have a truck that you drive to pick it up or does the farmer deliver to you? (If they deliver, where do they deliver to?)
    - □ I have a truck that I drive to pick it up
    - □ The farmer(s) deliver to me
    - □ If they deliver, where do they deliver to? - please explain below
    - □ Other (open-ended response space)

14. Do you have or use a warehouse of your own (aside from those at the Terminal) that you store the products you're selling?
    - □ Yes
    - □ No

- □ Other (open-ended response space)

15. How many trucks do you own for transporting produce? Or do you work with logistics companies or trucking companies?

    (Open-ended response space)

16. What is the name of your business?

    (Open-ended response space)

17. Thank you very much for participating in our survey! We are very grateful for the time and effort you spent answering our questions. Is there anything else you would like to mention that we haven't discussed yet about the OFT and its role in your business? Or anything else you would like to add?

    (Open-ended response space)

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Regional food system resilience and rural realities

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Abstract

Food system resilience is increasingly recognized as essential for sustaining food security amid shocks and disruptors such as extreme weather and climate change. Yet resilience planning is often limited in rural regions, where vulnerabilities may be higher and institutional capacity is constrained. This study examines how local governments and regional planning entities engage with food systems resilience across the 13-state Appalachian region. Appalachia provides a valuable case due to its high proportion of rural communities, elevated rates of

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Author Contributions

Research conceptualization (LKJ); Data collection & analysis (LKJ & JRS); Article drafting (LKJ); Article editing (LKJ & JRS); & Figure design (JRS).

Data Availability

Anonymized data is available by reasonable request to the corresponding author, Lia Kelinsky-Jones.

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Ethics

This research was reviewed by the Virginia Tech Institutional Review Board (protocol #23-374). Based on HHS and FDA regulations, the research was determined to not involve human subjects research.

Financial Interests

The authors have no competing interests to declare that are relevant to the content of this article.

food insecurity, and documented vulnerability to climate-related disruptions. At the same time, the region's strong agricultural assets make it well-suited to examine actions related to food systems resilience efforts. While resilience scholarship emphasizes the importance of locally rooted and self-organized food systems, regional approaches are often proposed as a means of connecting these localized efforts to enhance coordination across food systems and increase diversity, redundancy, and interconnectivity. Drawing on 32 group interviews with 113 public officials representing 167 counties, we apply Keegan et al.'s (2024) regional food system resilience concepts as a conceptual framework to analyze regional governance–oriented food system resilience actions. Our findings show that governmental actors primarily engage in facilitative roles, advancing food system efforts through food access initiatives, participation in networks, and support for local and regional supply chains. These efforts often build on locally embedded activities but remain unevenly coordinated across jurisdictions. We also find that local governments rely on nonprofit partnerships to advance food access initiatives in both routine times and in anticipation of or following an acute shock, while explicit attention to longer-term shocks, like climate change, remains limited. Despite evidence that locally organized efforts contribute to resilience, we find limited mechanisms for integrating these efforts at broader regional scales, underscoring gaps in multilevel governance. These findings suggest the need for future research on governance models that support coordination across jurisdictions, as well as practical efforts to strengthen planning capacity, integrate food systems into formal policy processes, and align short-term interventions with longer-term resilience planning.

Keywords
food security, Appalachia, governance, climate change, resilience, food systems

Introduction

Natural disasters, pandemics, and geopolitical conflicts continue to disrupt the ability of food systems to function, revealing the importance of building resilience, or the ability to adapt and persist in the face of disturbances (IPES-Food, 2022). Food systems resilience is often defined as "the capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate, and accessible food to all, in the face of various and even unforeseen disturbances" (Tendall et al., 2015, p. 19). This definition highlights the relationship between resilience and food security, and particularly a system's capacity to maintain food access during disturbances (Hodbod & Eakin, 2015). However, resilience is generally understood as a broader system-oriented concept that requires diversity, redundancy, ecological integrity, sufficient infrastructure, and local organization that enables food systems to adapt and persist over time (Worstell, 2025; Worstell & Green, 2017). For example, Cabell and Oelofse (2012) argue that resilient food systems must not only maintain food supplies during shocks and disruptions but also sustain the ecological systems and livelihoods upon which food systems depend. More recently, Zurek et al. (2022) emphasize resilience as involving not only the capacity to resist and recover from disruptions, but also the capacity for reorientation and transformation toward more sustainable and equitable food systems.

Due to the complexity involved, resilient food systems require intentional planning, as progress does not emerge spontaneously (Freedgood, 2024; Ruhf & Clancy, 2022; Zurek et al., 2022). Reflecting the importance of planning, a seminal text called for governmental planners to address food system issues such as community food security within their local communities (Pothukuchi & Kaufman, 1999). Since then, efforts by local governments to address food systems issues have increased (Raja et al., 2017). This study adopts a food systems governance perspective, examining how local governments and regional planning entities that plan on behalf of local governments respond to food security and increasing risks from climate-related disruptions, while recognizing that this lens captures only a part of the broader ecological and systemic dynamics of resilience.

Locally, food systems planning efforts often appear in comprehensive plans and climate action plans (Mui et al., 2018). The growing inclusion of food in climate action plans reflects how local gov-

ernments increasingly address food and climate objectives together to reduce agriculture's contribution to climate change while simultaneously advancing equity and food security (Cohen, 2022). A substantial body of scholarship further recognizes the critical role of local governments in climate mitigation and adaptation, given their authority over physical infrastructure, waste management, public procurement (including food), public lands, and transportation systems (Kelinsky-Jones & Levine, 2025; Nevens et al., 2013; Reid et al., 2023; Schiappa et al., 2023; Wang, 2012). However, these actions tend to be concentrated among urban localities as rural food security and resilience planning tend to be neglected (Freedgood, 2024; Ruhf & Clancy, 2022). This trend likely reflects the reality that rural governments often have less capacity to respond to climate issues, revealing an urban-rural capacity gap (Headwaters Economics, 2026). This climate and food-related planning gap between rural and urban communities is made worse because food system disruptions appear to negatively affect rural communities more than non-rural communities (Reidmiller et al., 2018). Finally, research tends to focus more on urban localities given the presence of planning to study. As a result, we suggest that investigating rural food system efforts in the face of climate disruptions is increasingly pressing.

Regional approaches are often proposed as a mechanism for improving resilience coordination and capacity, as larger geographic scales can increase interconnectivity, redundancy, responsiveness, and network formation (Blay-Palmer et al., 2026; Clancy & Ruhf, 2010). A region can comprise the area around a large city, multiple counties, multiple states, or mega-regions, such as in our case, Appalachia (Ruhf & Clancy, 2022). Local self-organization is one of several conditions for food systems resilience (Worstell & Green, 2017). Reflecting this, local food system policies are frequently treated as precursors to regional impact (Keegan et al., 2024; Tendall et al., 2015), yet we know little about how local efforts advance food systems efforts in the face of climate change and how they may be connected at regional levels, particularly in rural contexts (Clancy & Ruhf, 2010; J. K. Clark et al., 2021). To address this literature gap, we investigated food systems resilience actions among local governments and regional commissions across the U.S. 13-state mega-region of Appalachia. Importantly, this study does not assume the existence of a singular, coordinated food system across the entire mega-region. Instead, we examine how local governments and regional planning entities engage with food system resilience actions within and across jurisdictions. Accordingly, in this study, "regional" primarily refers to multicounty planning and governance activities. In doing so, this study provides one of the first large-scale empirical examinations of how local governments and regional entities are taking action around food systems efforts across Appalachia.

Regional Food Systems Resilience Conceptual Framework

Food systems resilience is a contested and multidisciplinary concept with roots across ecological, social, engineering, and food systems scholarship (Roosevelt et al., 2023). Existing scholarship variously emphasizes ecological resilience, adaptive capacity, self-organization, governance, food security, regional coordination, and systems transformation (Blay-Palmer et al., 2021; Green et al., 2017; Hodbod & Eakin, 2015; Roosevelt et al., 2023; Ruhf & Clancy, 2022; Tendall et al., 2015; Worstell & Green, 2017; Zurek et al., 2022). This study focuses on how resilience actions are operationalized by local and regional governmental entities. We selected this framework because it explicitly addresses regional food systems resilience.

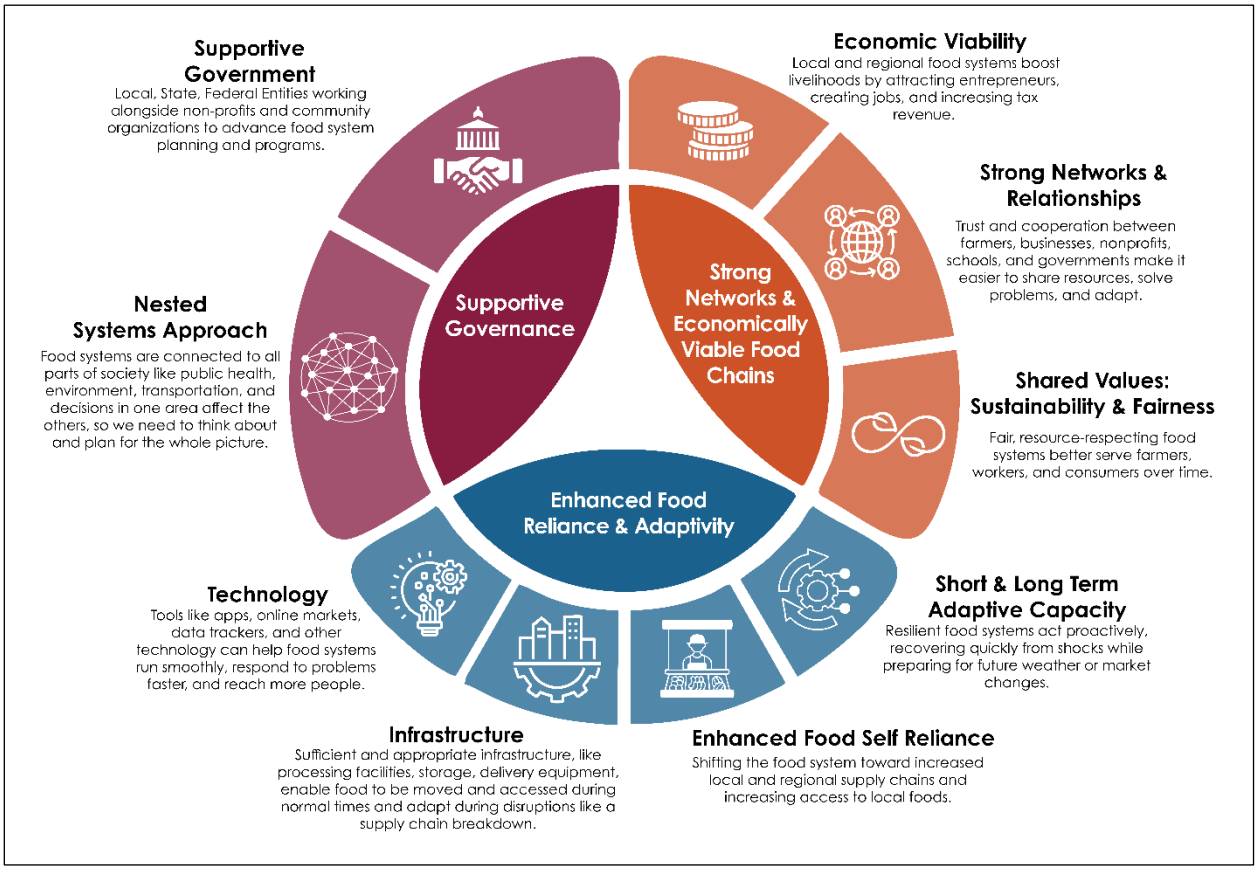
To guide analysis, we employed Keegan et al.'s (2024) regional food system resilience framework as a regional governance-oriented analytical lens (see Figure 1). We selected this framework because it explicitly addresses regional food systems resilience and coordination across scales, dimensions especially relevant to this study's focus on local governments and regional planning entities across Appalachia. At the same time, scholarship on regional food systems emphasizes that resilience is supported by the coordination and sum of local adaptive capacities, relationships, and actions (Clancy & Ruhf, 2010), aligning with broader resilience scholarship emphasizing the importance of local self-organization (Worstell & Green, 2017). We used Keegan et al.'s framework as a structured

approach for examining how public-sector actors engage with food systems resilience through planning, coordination, and institutional action at regional scales. Keegan et al. identify three core constructs that guided our analysis: (1) *supportive governance*; (2) *enhanced food self-reliance and adaptivity*; and (3) *strong networks and economically viable food chains*.

The first core construct, *supportive governance,* comprises multiple layers of governments working in a coordinated fashion across the system alongside nonprofit actors and other entities to address planning and policy efforts related to food systems and resilience (Clancy, 2014; Keegan et al., 2024). Under supportive governance, the two subthemes we derived include *supportive government* and a *nested systems approach*. Supportive government includes food system actions such as planning or policies, farmland preservation, multistakeholder visioning, incentives, or other governmental actions in support of local or regional food system efforts, and engaging with local nonprofits (Freedgood, 2024; Keegan et al., 2024; Zurek et al., 2022). More localized efforts alongside smaller governance institutions can support responsiveness and adaptation rather than larger, more centralized initiatives (Cabell & Oelofse, 2012). A nested systems approach emphasizes the interconnected social, economic, environmental, and institutional dimensions of food systems across scales (Keegan et al., 2024; Schipanski et al., 2016). At the same time, resilience scholarship cautions that higher-scale coordination can create tensions with local agency and self-organization when decision-making becomes disconnected from locally embedded adaptive capacities (Holling & Gunderson, 2002).

The second core element, *enhanced food self-reliance and adaptivity*, addresses the capacity of food systems to respond and adapt to disruptions through local and regional supply chains, infrastructure, appropriate technology, and adaptive capacities that can pivot more quickly than global

Figure 1. Regional Food System Elements Adapted from Keegan et al. (2024)



supply chains during a shock (Keegan et al., 2024). We identified four subthemes under this element, including *enhanced food self-reliance*, *short- and long-term adaptive capacity*, *infrastructure*, and *technology*. Enhanced food self-reliance suggests shifting the food system toward increased local and regional supply chains and increasing access to local foods for all (Keegan et al., 2024; Ruhf & Clancy, 2022). Blay-Palmer et al. (2021) further argue that regions that proactively co-plan for resilient food systems are better able to maintain food access and mitigate impacts on vulnerable populations during disruptions, highlighting the importance of pre-existing social support and food access infrastructures for resilience. Adaptive capacity includes both short-term responses to acute shocks and longer-term responses to build in robustness, or the ability of food systems to continue functioning under changing and uncertain conditions (Zurek et al., 2022). Sufficient infrastructure and appropriate technologies can help producers and other actors across the food system respond to changes both during shorter-term disasters and longer-term shifts (Keegan et al., 2024). For example, novel communication technology supported local food systems to shift during the COVID-19 pandemic (Thilmany et al., 2021).

The third core element, *strong networks and economically viable food chains*, emphasizes the importance of interdependency within a functioning food system because strong networks and relationships can support economic viability across a region (Keegan et al., 2024). Three subthemes emerged for this element: *strong networks and relationships*, *economic viability*, and *shared values*. Strong networks across food systems actors appear key to increasing policy and planning coordination within regional contexts (Blay-Palmer et al., 2021). Such networks speak to the importance of connectivity and coordination to support resilience through adaptive capacity, particularly when these connections include redundancy and flexibility (Worstell & Green, 2017). Second, economic viability speaks to the importance of local and regional food systems as shorter supply chains can support increased adaptation (Keegan et al., 2024). For example, during the COVID-19 pandemic, some regional food supply chains demonstrated flexibility and responsiveness by rapidly adapting distribution and logistics practices, including shifting toward direct-to-consumer delivery and alternative market channels (Marusak et al., 2021). Third, the shared values subtheme reflects how some food systems scholarship links resilience efforts with broader normative goals such as equitable food access, sustainable, and regenerative practices (Blay-Palmer et al., 2021; Ruhf & Clancy, 2022; Schipanski et al., 2016). We developed and employed a codebook based on the themes identified by Keegan and colleagues (2024) to conceptually guide the analysis of the group interviews we conducted.

Methodology

This study employed a qualitative research design to examine how public officials across Appalachia advance food systems efforts in the context of climate-related disruptions. We addressed two research questions: (1) how are local governments and regional planning commissions advancing food system efforts related to food security, and (2) how are these efforts addressing increasing risks to food security posed by climate change and extreme weather as a form of resilience planning? We addressed these research questions using semi-structured group interviews conducted over Zoom with public officials across the Appalachian region.

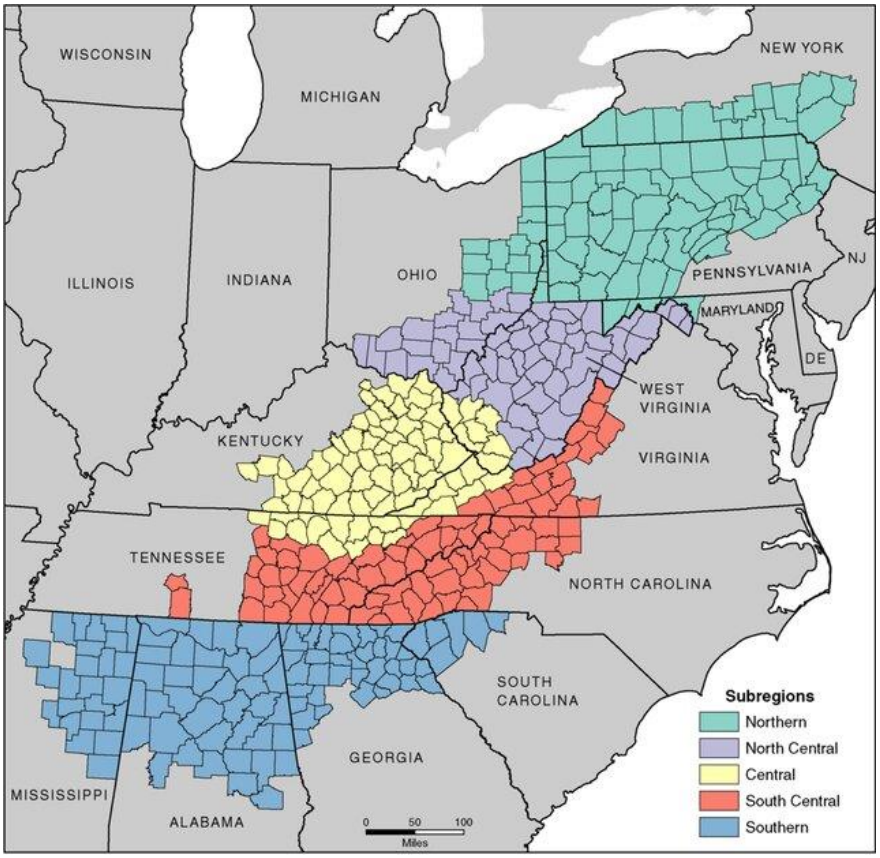
Case Selection and Context

We focused on the mega-region of Appalachia. We used the geographic boundaries established by the Appalachian Regional Commission (ARC), a regional economic development organization. The ARC defines Appalachia as a 13-state region encompassing 423 counties stretching from Mississippi to New York, covering 206,000 square miles or 331,524 square kilometers (ARC, n.d.; see Figure 2). The relative neglect of food systems planning efforts in rural areas (Freedgood, 2024) makes Appalachia a particularly valuable case due to its high proportion of rural communities (ARC, 2021a). Moreover, climate-related disruptions are predicted to worsen food insecurity (Reidmiller et al., 2018), and Appalachia experiences higher food insecurity rates than the national average (ARC, 2023). At the same time, recent scholarship emphasizes that resilience is unevenly distributed across

Appalachia, with some communities experiencing persistent poverty and food insecurity despite the resilience observed among many small farm households (Worstell, 2025).

Additionally, the region possesses significant food system assets that support food system development, including many small farms, strong cultural foodways, crop diversity, natural resource abundance, and successful models for food systems development in the area (Clark, 2015), which are supported by many layers of governance and community organizations working in tandem (Engle & Higgins, 2024). Despite this legacy, scholars have nonetheless identified a need for increased regional food system policy efforts (Appalachian Foodshed Project, 2016).

Figure 2. Appalachian Regional Commission Map of Appalachian Counties



Source: Appalachian Regional Commission. (2021). *Subregions in Appalachia*. https://www.arc.gov/map/subregions-in-appalachia/

Coal mining, mountaintop removal, and timber extraction negatively affected the ecological, social, economic, and cultural fabric of the region, resulting in higher rates of poverty, underdevelopment, and worse health and education outcomes compared to non-Appalachian counties (Austin & Clark, 2012; Clark, 2015; Gaventa, 2019; Newfont, 2011; Scanlan, 2011). Meanwhile, the region faces growing climate-related risks, including increased flooding and drought-worsened wildfire conditions (Arriens et al., 2024; Robbins et al., 2024; Sickels, 2022). Recent disasters illustrate these vulnerabilities: Hurricane Helene caused substantial agricultural damage across Southwest Virginia and western North Carolina in 2024 (Barlow, 2024; Russel, 2025), while eastern Kentucky experienced unprecedented flooding in 2022 (Graves, 2023).

Population and Sampling

We employed purposive sampling to identify public officials engaged in planning, community and economic development, sustainability, and food- or agriculture-related activities across three levels of governance: municipalities, counties, and regional commissions. We selected these positions because food system efforts often show up in sustainability, comprehensive planning, and community and economic development efforts (Deller et al., 2017; Mui et al., 2018). While these officials are not frontline or grassroots food systems actors, such as farmers, distributors, or food entrepreneurs, they nonetheless play important roles in shaping the policy, planning, infrastructure, and institutional conditions that influence food system outcomes. Moreover, there are very few government positions focused on food (Berglund et al., 2021), despite calls for such prioritization over two decades ago (Pot-

hukuchi & Kaufman, 1999, 2000). Reflecting this, food system efforts are showing up in non-food-related plans such as comprehensive, climate, and sustainability planning efforts (Mui et al., 2018). Together, these trends suggest that local and regional governmental actors are increasingly engaging with food systems issues, even when food systems are not their primary institutional focus.

At the municipal level, we focused on sustainability and food-related staff as these roles are most likely to integrate food systems planning into comprehensive plans and climate action efforts (Mui et al., 2018). We identified municipal-level participants through purposive sampling using membership networks of sustainability practitioners, including the Southeast Sustainability Directors Network (SSDN) and the Urban Sustainability Directors Network (USDN[1]). These networks represent established communities of practice for local government officials engaged in sustainability, climate, and food systems planning. We used publicly available member directories and the USDN urban agriculture working group to identify relevant localities, and then located appropriate staff (e.g., sustainability or food systems planners) through municipal websites. At the county and regional levels, we identified administrators and executives as well as planning staff involved in community and economic development, agriculture, environment, or conservation. Across these three populations, we invited a total of 839 unique individuals representing 15 local governments, 423 counties, and 74 regional commissions.

Between July 2024 and March 2025, we conducted 32 group interviews with 113 unique individuals from all 13 states. Collectively, respondents represented 167[2] counties (Figure 3) and one Virginia city, which we identify separately because Virginia cities are administratively independent of counties. Participants were primarily local government and regional commission employees, with occasional inclusion of Cooperative Extension or nonprofit partners; however, our analysis focused on governmental roles and actions only. Since our unit of analysis was organizational action, we did not collect participant demographics beyond location, role, and years in that position. Years of experience ranged from less than one year to over 30 years, with most participants having more than five years of experience in their current roles.

Group Interviews

We conducted exploratory group interviews (Frey & Fontana, 1991) to understand the experiences of participants. Through this qualitative method, we brought together participants from across Appalachia to gather the perspectives of multiple individuals simultaneously (Edmiston, 1944) and to capture any conversation, divergence, and agreement between participants. This method was also useful for "brainstorming" and exploratory discussion (Frey & Fontana, 1991), which aligned with the imaginaries-based question included in the larger study's interview protocol (Appendix A). These group interviews were conducted and recorded via Zoom, in order to accommodate individuals across the region, in a formal, arranged setting with semi-structured interview questions to spark responses from participants (Frey & Fontana, 1991). The group interviews consisted of 3 to 7 participants[3] and lasted up to 60 minutes. To mitigate the potential for groupthink or dominant voices, facilitators regularly moved person-to-person when introducing key questions in order to encourage individual responses before broader discussion and crosstalk among participants. Facilitators also explicitly welcomed differing perspectives and experiences throughout the interviews.

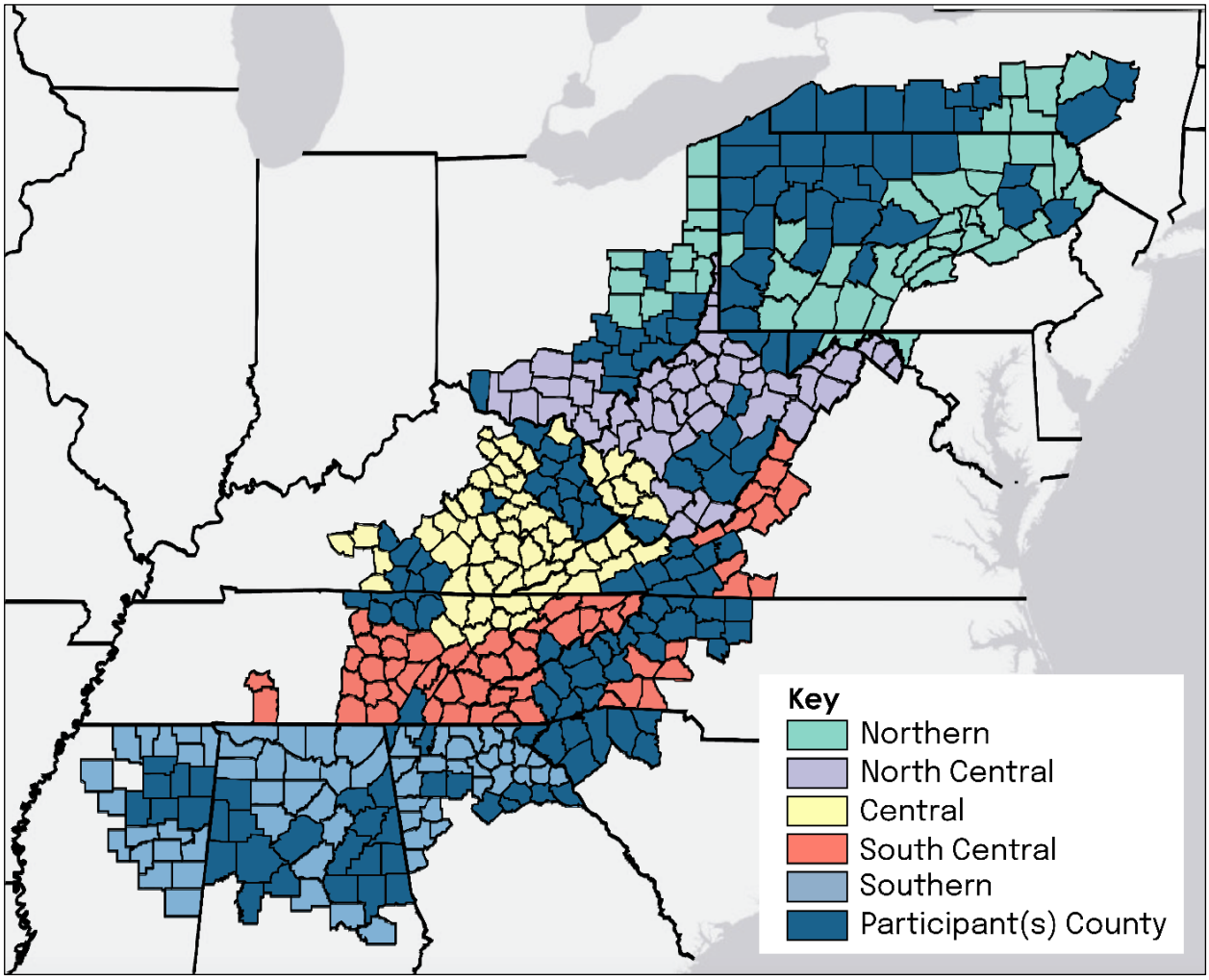
We employed a semi-structured group interview protocol (Appendix A), which addressed multiple research questions related to a larger project within which this study was embedded. Recognizing that food security has been used by some as an indicator of food system resilience (Hodbod & Ea-

[1] Despite the name, USDN is not solely composed of urban planners. For example, Blacksburg, Virginia, is a member and is considered a rural locality.

[2] The number of counties represented is higher than our number of unique respondents because 1 regional commission respondent represented multiple counties simultaneously.

[3] In three instances, we conducted individual interviews with people who could not make a group interview time.

Figure 3. Counties Represented in Group Interviews



Note: Due to our commitment to anonymity, the one Virginia city is not identified in this map.

kin, 2015), we first asked how their governmental organizations respond to food insecurity. Second, given the emphasis on adaptation within resilience frameworks, we asked how these entities respond to food insecurity in the context of increased risks from climatic changes. Our findings derive from these two lines of inquiry. To support clarity and consistency across interviews, we guided the conversation via shared slides that began with a map of Appalachia and a definition of food system resilience from Tendall et al. (2015) before shifting into the interview questions.

Trustworthiness and Credibility

We took multiple steps during data collection and analysis to ensure trustworthiness and credibility within this study as per Lincoln and Guba (1985). To address credibility and transferability, we aimed for and achieved data saturation through conducting a total of 32 group interviews with over 100 participants. After introductions were made at the beginning of the Zoom, we began an audio-only recording of the Zoom sessions to ensure accuracy and verbatim transcription; later, recordings were transcribed using Otter.ai software and checked for verbatim transcription by a graduate student worker for increased authenticity. During analysis, we reinforced credibility by consistent and frequent peer debriefing during data coding and theme formation (Lincoln & Guba, 1985).

Researcher Reflexivity

Researcher LKJ is a faculty member at a university in Appalachia whose work focuses on food systems resilience, policy, and community development. She holds a PhD in community development and food systems and previously held postdoctoral fellowships examining local government efforts related to sustainability, climate change, and food systems resilience. The impetus for this study was a previous collaboration with a local sustainability manager who indicated a need to understand food systems resilience actions at the local and regional governance scales in Appalachia. Researcher JRS was pursuing a doctoral degree in agricultural extension education, with an emphasis in life sciences communication, at a university in Appalachia during the study. Her work focuses on environmentally conscious agricultural practices and food systems resilience, reflecting an ongoing scholarly interest in the topic.

Analysis

As mentioned, we employed Keegan and colleagues' (2024) systematic review of regional food system resilience as an analytical framework to develop a codebook by operationalizing the key constructs and concepts articulated in their research. Using this existing schema supported our aims toward reproducibility, which supports rigor in qualitative research (Lincoln & Guba, 1985). Our coding team included both authors. Using our codebook, our analysis proceeded in four steps. First, we coded a transcript together in person using the codebook. As we worked through the first transcript, we refined our codebook by discussing each code's constructs, reaching consensus on what it meant, and adding examples from the transcript to the codebook. Second, we each coded a transcript individually. We met again, discussed the coding in our respective transcripts, reached consensus, and further refined the codebook. Third, we divided the remaining transcripts in half and coded them individually. During coding, we maintained memos and notes on observations and questions that we regularly shared with one another through email and meetings. To ensure transparency, we used analytical memos to record what we observed. Fourth, upon coding of all transcripts, we met and reviewed every coded statement, and the codes were attributed to ensure accuracy. We anonymized all respondent quotes (except for interviewees from Winston Salem, North Carolina, who requested attribution for their contributions) to reflect the categories of "municipality" (MG), "county" (CG), or "regional commission" (RG), followed by their unique participant ID number. Each quote represents an individual's statement on behalf of their organization.

Results

This section is organized according to the most prominent themes that emerged from respondents: *supportive government*, *strong networks and relationships*, *enabling self-reliance*, and *short- and long-term adaptive capacity*. Across the findings, local and regional governments are engaged in a range of activities related to food system resilience. These efforts span multiple dimensions—including food access before anticipated disruptions, networks, supply chains, and adaptive capacity—but vary in scope, scale, and level of coordination. While respondents described meaningful action within individual areas, these elements are not consistently integrated regionally across jurisdictions. The following sections explore how these efforts are expressed across key dimensions of regional food system resilience.

Supportive Government

Across our sample, respondents most often described their role in food systems efforts as facilitators, funders, and partners. Importantly, these findings reflect the perspectives and activities of governance and planning actors on behalf of their organizations, and do not capture the full range of food systems activities occurring at the community or grassroots level. Many resilience efforts, particularly those led by grassroots and civil society actors, operate outside formal governmental structures. As such, our findings illustrate how governmental actors engage within, support, and interact with these broader systems rather than serving as the sole agents of resilience.

Within this governance lens, actions aligned with supportive government were widely present across the sample, but varied in form, scale, and degree of institutionalization. Many participants de-

scribed supporting food system efforts through partnerships with nonprofit organizations, Extension services, and other public agencies, especially through funding, grants, and infrastructure development. For example, one respondent noted that "we have a really active big, large-scale food bank that has come to us a number of times for grants" (RG1_P04), while another explained how grant funding enabled significant infrastructure investment, stating, "we took an old carpet warehouse and converted that into a facility serving [our region]. … We also constructed a cold storage facility" (CG8_P32). Similarly, others emphasized the role of governmental entities in enabling food access through partnerships, such as establishing donation systems or providing support for food distribution; as one respondent shared, "we set up a donation station at our local farmers market to have people buy food that we donate to a local entity" (CG7_P26). Together, these examples illustrate how governmental actors frequently operate through resource mobilization and partnership rather than direct service provision.

At the same time, respondents consistently pointed to the central role of nonprofit and Extension systems in implementing food system activities on the ground. One regional commission participant stated that, "broadly speaking, the [redacted area] addresses food insecurity almost entirely from a nonprofit lens. That means a lot of little nonprofits" (RG3_P12). Others described how Extension systems facilitate food access and producer engagement, such as "working with our local producers on having direct access food boxes for folks that need support" (CG16_P69), or noted that organizations like food hubs operate outside of government, with "county involvement, primarily through our Extension Service" (CG16_P69). In many instances, participants framed their role as supportive rather than directive, emphasizing coordination rather than implementation. This dynamic was also reflected during disaster response, where one participant explained that food access during a crisis was "all volunteer-based through church organizations and local community groups. That's how we dealt with that" (CG15_P63). These accounts illustrate how governmental actors are embedded within broader nonprofit and volunteer networks. In some cases, these network-building efforts extended across multiple counties.

Formalized food system positions or plans in government were relatively rare, consistent with broader national patterns (Berglund et al., 2021). Most respondents indicated that food-related work was embedded within broader planning roles rather than institutionalized through dedicated positions. As one individual explained, their role was "situated in the planning department … working in food systems and supporting a food council," highlighting an emerging but still uncommon form of institutionalization. More frequently, food system efforts were incorporated into existing planning frameworks. For instance, one respondent explained that food system concerns emerged through comprehensive planning, noting, "we did a comprehensive plan in 2013. … We started to really recognize just how devastating some of our food deserts are. We did a number of zoning amendments to try and increase food production" (MG3_P10). Others described integration into climate planning processes, with one noting that "support for this work was also called up in our municipal climate action plan" (MG1_P03). These examples suggest that food system engagement often occurs indirectly through existing planning mechanisms rather than as a standalone area of governance.

Some respondents also described policy tools that indirectly support food system resilience, particularly through land use and agricultural preservation. For example, one county employee explained, "our county recently updated their countywide ag plan. … In the next couple of years we're really focusing on land preservation" (CG9_P34), while another described a statewide program where "we buy at the development rates so that farm stays in farm production in perpetuity" (CG19_P83). Others highlighted zoning changes intended to reduce pressure on farmland, such as implementing minimum acreage policies for residential development. These efforts demonstrate how supportive governance may occur through policy instruments that shape the broader conditions of the food system, even when food systems are not the primary focus.

Taken together, these findings suggest that supportive governance across the sample is charac-

terized by facilitative, partnership-based approaches in which governmental actors enable, rather than directly coordinate, food system efforts. While these arrangements reflect the multi-actor collaboration emphasized in resilience literature, they also highlight how governance operates as one component within a broader system of actors. As a result, supportive governance appears active but unevenly structured across the region, with most efforts operating through dispersed programs and partnerships rather than coordinated, system-level planning. This pattern also shapes the development of networks, supply chains, and adaptive capacity described in subsequent sections.

Strong Networks and Relationships

Strong networks and relationships are widely recognized as essential for food system resilience, as they increase communication and coordination among actors. Across respondents, network-building efforts such as coalitions, councils, or networking groups were present but are uneven and typically informal, with relatively few examples of sustained, institutionalized coordination across jurisdictions. One regional commission official described participation in a loosely organized statewide effort:

> I am allowed to participate in a semi-established organization called the [state] food system collaborative. … It's a real loosely formed organization of farmers, food hubs, commissions, and other agencies across the state [and] universities that are interested in food systems. We address food security issues, but we fail to address climate change. (RG2_P07)

For example, one regional commission described coordinating a food systems council that is "representative of the 12 counties that we serve … working across the food system and partner organizations from each of those counties" (RG3_P14), illustrating the potential for regional coordination and convening at a broader geographic scale.

At the same time, some local governments described more active convening roles at the county level with an eye toward connecting resources and local procurement. One county official explained:

> We have a coordinated platform in the county. … We meet monthly, and we're sharing info on who may have a better lead on a producer that we can purchase from, the different barriers that the [Municipality] Community Food Bank is facing in sourcing food. … Ultimately our goal is to figure out some different grants or dollars to go towards a coalition … versus everyone going their own direction. (CG18_P79)

Similarly, another county respondent described coalition-building driven by a community health assessment:

> Our Community Health Assessment [identified] … our health priorities, we have three [and] one was food security. As a county, we are bringing partners together [in] a coalition, and we are seeing what our county has to offer, what we need, what we have, doing an assessment. We have WIC staff … SNAP, and we have food pantries around our county. (CG15_P64)

These examples within this theme point to meaningful network-building activity. However, such efforts were relatively rare among the 113 respondents and were less commonly described at a regional scale. This limits the connections needed for a resilient food system to function across geographic and administrative boundaries.

Enabling Self-Reliance

Reorienting food systems toward greater local and regional self-reliance is a central component of resilience, as it can reduce dependence on longer, global supply chains that are vulnerable to shocks. Within this theme, self-reliance primarily took the form of efforts to increase local food production, improve access to locally produced foods, and support local or regional supply chain activities.

Respondents described a range of strategies, including farmers markets, procurement from local producers, community food production on public land, and support for food enterprises. For example, one respondent described efforts to connect local producers with food access initiatives:

> We have a farmers market program that allows our WIC recipients to purchase fresh produce, and we have seen a tremendous decline in those using that program. We came up with a solution … a cooperative of about 15 farmers … is going to be providing veggie boxes. (CG11_P42)

Others focus on the local entity growing food. The respondent from Winston Salem, North Carolina, exemplified this by stating, "we own a large hydroponic greenhouse in a food desert, and have it contracted out to a local nonprofit to grow food, and they just give it out." A county employee described a similar strategy: "community gardens that operate within our park system. Everything harvested from our share rows … is donated back to our emergency food providers" (CG18_P79). These efforts reflect locally embedded strategies to increase food availability and access, although they are often implemented through specific programs or partnerships that may be vulnerable to priority changes rather than broader systemwide shifts in production or distribution.

Additional strategies focused on strengthening local markets and food enterprises. One regional commission described a "[US]$3 million [grant] that will go towards capacity-building and credit enhancement to support food retail and food enterprise in [their] region," an initiative that came out of their "food system assessment to make lending more accessible … with a specific emphasis on BIPOC and women-owned retail and food enterprises" (RG3_P14). Another regional entity used an ARC grant to "look into bringing back food additive or value-added food product. We did this multicounty approach trying to get an added value to some sort of product." They elaborated to say, "unfortunately, that fell apart, like many of the things that go on here. Part of that has to do with the mentality that is bred and lives within the confines of our county" (CGF17_P77). This example highlights the difficulty of sustaining cross-county initiatives over time that span bureaucratic boundaries.

Collectively, these strategies reflect promising movements toward self-reliance. Still, their scope remains limited. Most of the efforts that were described affect local food on the margins of existing systems rather than structurally reorienting toward production and/or procurement toward regional supply chains. The examples of infrastructure investment and value-added development stand out because they are uncommon, pointing to an underutilized mechanism for building continued self-reliance across the region.

Short- and Long-Term Adaptive Capacity

Adaptive capacity is a nuanced construct to assess. It is often considered latent—observable once a disaster or disruption happens (Chodur et al., 2018). Of the four emergent themes, adaptive capacity was the one where the gap between aspiration and action was the most apparent; respondents acknowledged the need for a climate-responsive food system and planning for it but described limited capacity to pursue it. In our sample, the most common adaptive strategies observed were to include food in emergency planning to address short-term disruptions, and to address climate risks to food security and production for a longer-term vantage. Importantly, this area of inquiry was one in which multiple respondents wanted to do more but did not know how to. One respondent stated:

> A lot of [food system resilience efforts are] done by grassroots organizations. … It's not to say that the county doesn't want to be involved … maybe they just don't know how. (CG4_P10)

Among those attending to adaptive capacity, some entities through their "food council [have] been hosting events and having discussions around how to build resiliency in [their] regional food systems" (RG3_P14) or using their "resilience program [to] look at risks and how to address planning for the future" (RG5_P17).

Some respondents spoke of their partnerships with the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) or Extension to support climate-adaptive practices among farmers, one stating, "we partnered with [USDA] NRCS which funds half my position, and the USDA has some climate resiliency [efforts] …

that address landscape scale climate-related aspects" (CG4_P11). As far as partnerships with Extension, it mostly took the form of monetary support, exemplified by a participant's statement, "they come to the county and tell us what they need budgetary wise. … That would be our engagement and involvement when it relates to weather" (CG9_P35).

Garnering municipal support for climate-related food system work emerged as a challenge for regional commissions in our sample. This is represented by the following statement from a regional commission employee:

> It's hard to get municipal governments to sign on because some of the climate goals that they have to agree to [are] a challenge. … [We] say, "look you've suffered from how many floods. … We've got to do something." (RG1_P04)

Other municipalities demonstrated early engagement with climate-related food system planning, with one individual explaining, "[in] our climate action plan … local foods are mostly in there because it focuses on greenhouse gas reduction and elimination" (MG1_P01). Another entity called up, "support for this work in our municipal Climate Action Plan that was adopted last year and mentioned in our comp plan" (MG1_P03).

From a short-term disaster perspective, emergency food provision emerged as a dominant theme. Several of these group interviews took place during the historic Hurricane Helene, which caused significant devastation, particularly in the Central Appalachian region. Some respondents described their response to the hurricane, revealing a heavy reliance on their civil society organizations, with one stating, "we were hit hard with Helene and a lot of our food resources were all volunteer based" (CG15_P63). Others discussed their county's direct action, although not necessarily in relation to Helene; one noted, "we distribute shelf-stable meal packs twice a year in preparation for hurricane season and ice storms. So, senior clients have five to eight days' worth of meals" (CG18_P79). One municipality has an effort that seeks to connect disaster preparedness with equity:

> … the final area, which is nascent, and hopefully we'll get more traction, is incorporated within the climate justice initiative with some more emergency food preparedness and equity. The hope there is that there's community-led dialog, not only about what we do in disaster time, but how we care for the community's food needs. (MG1_P03)

These findings reveal a tension at the heart of adaptive capacity across Appalachia: short-term, emergency-focused responses are more common and more institutionalized than long-term climate planning. This is the case even though respondents increasingly recognized the inadequacy of that orientation; for example, one municipal sustainability official stated:

> We're like in reaction mode. … We're not addressing [climate risks to food]. That's why I'm here … We did our climate vulnerability assessment, [and] it just became clear that food insecurity is only going to get worse, and I didn't see that there was much happening to plan at a larger scale. (MG2_P07)

The reactive nature evident across much of the sample—relying on volunteer networks and civil society organizations during acute events like Hurricane Helene—suggests that adaptive capacity remains more latent than enacted, and that explicit investment in longer-term planning infrastructure will be necessary to move the region forward toward genuine resilience. Across all four themes, a consistent pattern emerges: efforts are unevenly developed and rarely co-occur in integrated ways. While respondents described activities aligned with individual elements of resilience, few cases demonstrated coordinated action across governance, networks, supply chains, and adaptive capacity simultaneously.

Discussion

Food system resilience requires governance systems that span multiple levels and actors, including governmental, nonprofit, and private-sector actors (Clancy, 2014; Keegan et al., 2024). Such actions are particularly impactful at regional scales through

networks and coalitions with shared goals (Ruhf & Clancy, 2022). In the U.S., this is challenging, as bureaucratic systems across geographic boundaries were not established with regional cooperation in mind (Clancy, 2014). To our knowledge, this study offers one of the first analyses of local governments' and regional commissions' efforts to increase food system resilience in the largely rural mega-region of Appalachia. Across the sample, respondents described a range of activities aligned with elements of resilience, including food access initiatives, network building, support for local supply chains, and short-term adaptive planning. However, these activities were typically facilitative in nature, relying on partnerships, funding, and coordination rather than direct implementation, and they rarely reflected integrated, long-term planning for climate-related food disruptions.

A central pattern emerging from these findings is that food system efforts are distributed across diverse actors, with local governments and regional commissions frequently acting as conveners or partners in food systems activity. While this approach aligns with regional governance scholarship emphasizing distributed capacity and collaboration (Clancy, 2014; Keegan et al., 2024), respondents rarely described coordinated, regional efforts. When regional efforts were mentioned, they were typically limited to specific projects or relationships rather than integrated strategies connecting food access, production, and planning across jurisdictions.

Many respondents noted that food banking entities are central efforts to ensure food security, and in some cases, contribute to short-term resilience. Some officials described coordinated food access efforts in routine contexts and during crises. These responses may support resilience by enabling the rapid redistribution of food and assistance to vulnerable populations during crises, especially within city-regions (Blay-Palmer et al., 2021). However, respondents did not consistently describe these initiatives as integrated within local or regional production systems. As a result, while they support food access, their contribution to longer-term resilience through increased self-reliance is limited since they rely primarily on external food inflows. In contrast, food access programs that procure from local or regional producers may strengthen supply chains, support farmer livelihoods, and improve access to local foods, all of which have been identified as important components of regional resilience (Keegan et al., 2024). This pattern also reflects a broader critique of the U.S. charitable food system, which tends to rely on surplus production and external supply chains rather than addressing underlying structural inequalities (Lohnes & Pine, 2023).

This distinction reflects a broader tension within resilience scholarship between short-term responses that emphasize "recovery" and longer-term transformation or reorientation that could address structural weaknesses (Zurek et al., 2022). Across the sample, governance activities were more commonly oriented toward immediate needs rather than coordinated, long-term planning for climate-related disruption, a limitation that respondents themselves recognized. This orientation likely reflects the broader governance conditions under which these local actors operate, as policy development and planning processes are often shaped by shorter time horizons, resource constraints, and the incremental nature of policy change (Baumgartner et al., 2018; Clancy, 2014). These dynamics may be particularly pronounced in rural regions such as Appalachia, where local governments often face limited staffing, funding, and technical capacity (Headwaters Economics, 2026). In Appalachia, these challenges may be further compounded by the legacies of extractive industries, environmental degradation, and ongoing social and public health challenges that compete for governmental attention and resources (Austin & Clark, 2012; S. Clark, 2015; Marshall et al., 2017; Schalkoff et al., 2020). This highlights the need to engage resilience not only as adaptive capacity, but also as a framework that accounts for governance conditions and structural change.

Conclusion and Recommendations

This study examined how food systems resilience is operationalized in regional governance contexts, revealing a consistent emphasis on short-term interventions over longer-term structural change. Across Appalachia, local governments and regional commissions are actively engaged in food system

efforts, but their roles are predominantly facilitative, focused on coordination, partnership-building, and programmatic support rather than leading integrated, systemwide initiatives.

Cumulatively, these findings suggest that food system resilience efforts are best understood as forms of supportive governance that can enhance short-term adaptive capacity in collaboration with civil society but are insufficient alone. The challenge facing Appalachia is not a lack of activity, but the limited integration of food system efforts across county lines and planning horizons. Moving from reactive responses toward longer-term resilience will require governance structures capable of connecting local initiatives, supporting adaptation, and fostering regional collaboration. More broadly, these findings highlight the importance of embedding food systems within formal planning and policy processes. Doing so may help align short-term interventions with longer-term adaptation goals while strengthening coordination.

This work also points to important opportunities for future research. Future inquiry could explore governance models for regional coordination across Appalachia and other regions with large rural environments. A significant amount of work has been done exploring regional food systems and governance in the Northeast (see Clancy et al., 2017; Palmer et al., 2017; Ruhf, 2015; Ruhf & Clancy, 2022). Similar work is needed in Appalachia, including comparisons across subregions. We also suggest that investigating food-related networks that exist in concentrated rural areas not adjacent to urban centers would be fruitful to learn more about their organizing efforts toward food system change, extending work on city-region food system resilience (Blay-Palmer et al., 2021). There is also a need to systematically assess governance capacity across the mega-region by inventorying food-related positions, identifying food system goals in local plans, and evaluating intervention effectiveness over time. Further investigation of regional self-reliance potential could also help clarify the role of regional supply chains in supporting resilience.

From a practice perspective, our findings highlight both constraints and opportunities for policy, governance, and decision-making. Although bureaucratic structures in the U.S. system can hinder coordination across jurisdictions, local and regional governmental actors remain uniquely positioned to convene diverse stakeholders around more integrated, whole-systems approaches to food system resilience. This includes facilitating cross-sector networks that connect food access, production, distribution, and planning efforts, which are often addressed in isolation. Our findings also suggest that local and regional governments should embed food systems within comprehensive planning processes and those focused on hazard mitigation and economic development. By leveraging their convening and planning strengths, these entities can help align short-term interventions with longer-term goals, contributing to more coordinated and resilient food systems. We suggest that local and regional governments undertake food system assessments to identify assets, gaps, and interdependencies while convening stakeholders around shared goals. Several respondents pointed to this type of process as an entry point for more coordinated food system planning and action.

Finally, regional economic development entities such as the Appalachian Regional Commission could play a more active role in supporting these efforts by incentivizing multicounty collaboration, funding regional planning initiatives, and facilitating knowledge exchange across communities. Although ARC supported a report on local food systems and economies in 2022, no respondents indicated current support from ARC in their region for improving local food system efforts. This suggests an opportunity for ARC to support and strengthen emerging regional networks that contribute to food system resilience.

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Appendix A. Semi-Structured Group Interview Protocol

1. Begin by presenting this definition of food system resilience, "The capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate, and accessible food to all, in the face of various and even unforeseen disturbances" (Tendall et al., 2015, p. 19).
    a. How does this definition resonate (or not) with you?
    b. Is anything missing from this definition? Or unclear?
    c. Would you define food system resilience differently?
2. Recognizing the importance of food security to the food system resilience definition, we would welcome you to answer:
    a. Is addressing food security part of your organization's mission?
    b. Is your organization already working on food security? If so, how?
3. Changing precipitation patterns, extreme heat, and intense storms are predicted to worsen existing food security issues.
    a. To what degree is your organization addressing food security with these changes in mind?
4. If you had a magical wand, what local or regional policies or programs do you think would be effective to address food system resilience?
    a. What about state policies? Or federal?
5. Are you already implementing, actively pursuing, or considering any of the policies and/or programs you listed from the previous question?
    a. How would your organization like to respond to food system resilience? What are the barriers?
6. What are the understudied issues, challenges, or critical needs when it comes to food system resilience?
    a. Can you think of particular research or data that would help create better policies or programs?

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"We use it … and we need it now": An assessment of internet and technology use among farm owners and managers

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Abstract

Many agricultural producers live and work in rural areas that have been left behind in broadband internet expansion. A lack of digital inclusion of agricultural communities can stymie agricultural producers' participation in e-commerce and marketing, use of precision agriculture, and access to information. To better understand how farm owners and managers access the internet and their digital skills, we conducted a mixed-methods research project using focus groups (N = 4) with participants (n = 26) living in four North Carolina (NC) counties in 2023. We used thematic analysis to qualitatively analyze the focus group data. To quantitatively assess emerging themes, we then conducted a survey of farmers (n = 113) at a statewide farm show in NC in 2024. We calculated descriptive statistics for the survey data, including

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demographics (gender, race, crops or livestock produced, acreage farmed) and experience with devices, social media, and troubleshooting. We identified three overarching themes: (1) experiences with internet and digital technologies; (2) impacts of internet access and digital technology, including farmers' reflections on the critical need for internet connectivity for farm operations and perceptions of negative consequences of not having adequate connectivity; and (3) sentiments toward internet, specifically farmers' frustration with the current state of connectivity options and opinions on initiatives to improve connectivity. Findings reveal an imperative for better digital inclusion of farms and agricultural communities across NC.

Keywords
agriculture, farmers, internet access, internet use, digital technology, computers, smartphone, computer literacy

Introduction and Literature Review

Researchers have moved from documenting differences in access to technology—the "digital divide"—toward a more holistic approach focused on digital inclusion. Digital inclusion emphasizes access to the internet and technology *as well as* the skills and knowledge that allow "all individuals and communities [to] have the information technology capacity needed for full participation in our society, democracy, and economy" (National Digital Inclusion Alliance, n.d., para. 3). Access to information has been identified as a determinant of health and is increasingly being recognized as a precursor to other social determinants of health (Early & Hernandez, 2021; Graham et al., 2024). Drawing on a social ecological framework, researchers have highlighted the importance of digital skills as well as demonstrated how policies, infrastructure, and community characteristics can influence digital inclusion (Jahnel et al., 2022; Katz & Gonzalez, 2016).

There are substantial discussions in the literature on rural broadband and the importance of digital skills for agriculture and community development (e.g., LoPiccalo, 2022; Syafuddin & Meidina, 2023). Agricultural producers often live and work in rural areas, which have historically faced challenges with broadband infrastructure and, in some cases, any internet access. Precision agriculture, social media marketing, e-commerce, and agritourism are all important parts of modern food systems and influence economic development in agricultural and rural areas. For example, the U.S. Department of Agriculture (USDA) estimated that broadband connectivity, along with the inclusion of precision agricultural technologies, could generate a minimum of US$47 billion annually in economic benefit (USDA, 2019). However, economic development is stymied where internet is not available, is

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Ethical Statement
This study was approved by the East Carolina University and Medical Center Institutional Review Board (#22-001454). Focus group participants provided verbal informed consent and survey participants provided verbal informed consent prior to participation in the study.

Declaration of Conflicting Interest
All authors declare that they have no conflicts of interest.

not fast enough, or requires knowledge and skills that are not readily available.

North Carolina (NC) is a state with a large rural population, and agriculture represents an important part of the economy. NC's rural population is the second largest in the country (Cline, 2023). Agriculture contributes more than US$111 billion annually to the state's economy and is the second-largest land-use category in NC, accounting for 20% of the state's land and open-water area (NC Natural Heritage Program, n.d.; Walden, 2024). In 2021, the NC Department of Information Technology released a report on internet connectivity and farms, finding that 90% of the 1,250 respondents said reliable high-speed internet is "extremely important" or "very important" for conducting farm business (NC Department of Information Technology, 2021).

In the United States, there have been substantial federal and state investments to bring broadband and digital skills to rural areas, including farms. These investments have included emergency COVID-19 response (e.g., Baker et al., 2021; Cofie et al., 2022) funds to install broadband service in areas that have not had service (e.g., Valentín-Sívico et al., 2023), and, more recently, educational efforts to improve digital skills (e.g., National Telecommunications and Information Administration, 2025). Indeed, the American Rescue Plan Act (ARPA) has provided billions of dollars to advance digital inclusion, including in rural areas. Using federal and state funds, NC's Division of Broadband and Digital Opportunity has supported assessment, mapping, planning, and infrastructure development as part of a statewide effort to bring broadband internet to rural areas and across the state.

Researchers have called for greater focus on analyzing internet outcomes, which involves the impacts internet use has on individuals, groups, and society (Scheerder et al., 2017). While prior research has examined digital inclusion among migrant and seasonal farmworkers specifically, including access to and costs of internet for farmworkers in NC (Lee, 2024), less is known from the perspectives of owners and managers regarding their experiences with internet access. Thus, to address this gap in the literature, inform digital inclusion efforts in rural areas, and advance technology deployment and precision agriculture efforts, we sought to explore digital inclusion among NC farm owners and managers. Specifically, we used both qualitative and quantitative data to address the following research questions:

(1) What are NC farm owners' and managers' experiences using the internet and digital technology?
(2) How does access to digital technology impact NC farm owners and managers?
(3) What are NC farm owners' and managers' perceptions related to internet infrastructure in rural farming communities?

The focus on owners and managers offers a unique perspective on the digital inclusion challenges experienced by the agricultural community and highlights the need to consider the digital technology and internet needs of both farmworkers and owners.

Research Methods

We used a sequential exploratory mixed-methods design, in which we conducted qualitative research via focus groups to inform a subsequent survey, which we used to quantify themes identified in the qualitative data. This project was part of a broader statewide effort to understand digital inclusion for agriculture and agricultural workers in NC, funded by the Institute for Museum and Library Services. The project and related data collection tools were informed by an advisory panel representing multiple sectors and lived experiences, including broadband infrastructure, library sciences, and digital inclusion. The East Carolina University and Medical Center Institutional Review Board approved the study's procedures (#22-001454).

Next, we describe the design and implementation of the qualitative data collection, followed by the design of the quantitative data collection. We then describe the analysis of both types of data.

Qualitative Data

To better understand farm owners' and managers' perspectives and experiences with digital access, digital literacy, and digital technology use, we col-

lected qualitative data through focus group discussions.

Focus Group Discussion Guide Development
Study team members designed a focus group discussion guide, and state partners and advisory panel members reviewed it. The guide consisted of 23 core questions. We included questions in five domains: digital access, digital literacy and resilience, searching for information, information sources utilized, and demographic questions. The focus group guide is available in an institutional repository (Bloss, 2025).

Qualitative Data Collection
We held focus group discussions from January 22 to March 28, 2023. County Cooperative Extension agents, who regularly interact with and provide programming to farm owners and managers, assisted us in recruiting focus group participants. Two members of the research team (JN, EH) conducted the four focus group discussions using a semi-structured discussion guide. Both facilitators received training in conducting focus group discussions. We held focus group discussions at county Cooperative Extension offices or, in one case, at a private room in a restaurant. We audio-recorded focus groups (average length: 64 minutes) and professionally transcribed them using a smooth verbatim protocol. Participants received a US$30 gift card and a meal.

Focus group discussions took place in four NC counties, for which we have replaced the actual county names with pseudonyms to maintain participants' confidentiality: Banks, Crawford, Reynolds, and Sanders. We selected these counties based on their distribution across the state's three regions (western, central, and eastern) and their agricultural diversity. Banks County, located in western NC, is predominantly white non-Hispanic/Latine, and approximately half of its population lives in a rural area. Crawford County, located in central NC, is predominantly white non-Hispanic/Latine, and nearly a third of the county's residents identify as Black/African American. Almost all the county's population lives in a rural area. Reynolds County, also located in central NC, has one of the highest numbers of farms in the state. The county is predominantly white non-Hispanic, with approximately 15% of residents identifying as Hispanic/Latine. More than half of the county's population lives in a rural area. Sanders County, located in eastern North Carolina, is among the top counties in NC for agricultural sales. The population of Sanders County is relatively diverse, with approximately half of residents identifying as white non-Hispanic/Latine, about 25% as Black/African American, and about 20% as Hispanic/Latine. About half of the county is designated as farmland or forestry, and most of the population lives in a rural area. Across all four counties, a majority of farms are owned or operated by a family.

Quantitative Data
To further examine digital access, digital literacy, and digital technology use among North Carolina farm owners and managers, we developed and administered a cross-sectional survey informed by findings from the qualitative phase of the study.

Survey Development
The information garnered from the focus groups informed the development of the survey questions. Thematic findings that informed survey items relevant to the present study included access to and use of digital technology (e.g., the internet and computing devices) among owners and managers. Software and device/internet troubleshooting questions were adapted from existing items (Pieterse et al., 2018; Santo et al., 2018). The study team developed additional sections of the survey, including questions on demographic information, device access, and library use. The advisory panel reviewed a draft of the survey codebook for face and content validity. The panel members received a draft of the codebook for them to provide an initial round of written feedback. After receiving the feedback, the study team met with the advisory panel to review the feedback and gain additional insights to help refine the codebook. We pilot tested the survey with one farm owner and additionally received feedback on the survey from someone with farming experience who currently provides programming to farm owners and managers. The survey codebook is available in our institutional repository (Bloss, 2025).

Survey Items

Device access was assessed using three items, where participants could respond with "Yes," "I can borrow one," or "No." Items included "I have my own laptop or desktop computer," "I have my own smartphone," and "I have my own tablet."

Social media use was assessed through one question: "Do you use any of the following?" Participants were able to select one or more of the following: "Facebook," "GroupMe," "Instagram," "WhatsApp," "Snapchat," "TikTok," "YouTube," or input their own answer through an "Other" option.

Device and internet troubleshooting were assessed through six statements: "When there is a problem with my phone, computer, tablet, or other device, I know how to solve it"; "When there is a problem with my internet connection, I know how to solve it"; "If I don't know how to solve a problem with my device (e.g., phone or computer) or internet connection, I know who to ask for help to resolve it"; "I am afraid of using my phone, computer, tablet, or other device. I try not to ruin anything"; "I adopt new technologies such as new apps, devices, or software easily"; and "I tend to use apps, devices, or software that I am familiar with rather than learning new ones." Participants could indicate "Yes," "Sometimes," or "No" for each statement.

Quantitative Data Collection

We utilized a cross-sectional survey design to assess farmer internet access and use. We recruited participants at a farm show in NC from January 31 to February 2, 2024. Trained data collectors approached participants as they entered or left exhibition areas, pesticide applicator recertification classes, and association meetings, and the data collectors completed a consent form with all participants prior to starting the survey. Participants completed surveys on Apple iPads using the Qualtrics offline app. Participants received a US$25 gift card upon survey completion. We required participants to be over the age of 18 and to be NC residents. A total of 113 farmers from 35 (out of 100) counties in NC completed the survey.

Qualitative and Quantitative Data Analysis

Qualitative data analysis entailed a thematic coding approach. Two members of the research team first worked together to code focus group transcripts using the annotation/comment feature in Microsoft Word. Three members of the research team (LC, EH, JN) next created a preliminary codebook using deductive codes from the interview guides and inductive codes that emerged from the transcripts. Then JN and EH applied the preliminary codebook to two transcripts. The coders compared their coding, reached consensus, and refined the codebook as needed. The two coders then applied the codebook to the remaining focus group transcripts using NVivo software (version 14), with members of the research team meeting regularly to discuss discrepancies. Upon coding completion, members of the research team (EH, JN, ER) used the code outputs to develop summaries and matrices comparing the perspectives of the farmers by location. Three authors (LC, EH, JN) then used the coding matrices to identify themes, which could collapse or cross codes in the matrices. The themes were identified using an immersion-crystallization process that seeks to give meaning to the data based on reflection and probing for alternative interpretations of participants' views on and experiences with internet and digital technology (Borkan, 2022). Regarding positionality, the analysis team had representation by gender and racial identity, level of formal education (from BS to PhD), and disciplinary background, including anthropology, education, the humanities, and public health.

For the quantitative data analysis, we extracted the data from Qualtrics and re-coded it for ease of use in analysis programs. We used SPSS V.29.0.1.0 (IBM, Chicago, Illinois) to analyze data. We utilized descriptive statistics, such as frequency distribution, to summarize variables. Because survey participants' ages were not collected and convenience sampling was used, additional statistical analyses beyond descriptive statistics were not performed. We treated data as missing at random and used pairwise deletion; that is, we only omitted missing responses for the variables of interest for each descriptive analysis.

Results

Focus group participant demographics are reported in Table 1. Most participants were male (69%), white (96%), and between 50 and 59 years old (46%). Table 2 shows the demographics of survey participants. Survey participants were mostly male (83%) and white (92%). The most commonly produced crops and livestock raised were soy (43%), corn (35%), and beef cattle (34%).

Our qualitative results fell into three overarching themes. The first theme captured farmers' experiences with the internet and digital technologies. The second related to their perceptions of positive and negative impacts of using internet and technology. The third captured farmers' sentiments relating to the internet and technology. Survey results provided additional insight regarding the themes.

Table 1. Focus Group Participants' Demographic Characteristics (*n* = 26)

Demographic characteristic	*n*	%
Gender		
Men	18	69.2
Women	8	30.7
Race		
White	25	96.0
Black/African American	1	4.0
Age[a]		
29 & younger	1	4.5
30-39	3	13.6
40-49	0	0
50-59	10	45.5
60-69	5	22.7
70 & older	3	13.6
FORHP Classification[b]		
Rural	9	40.9
Not Rural	13	59.1

Note. FORHP stands for Federal Office of Rural Health Policy (Health Resources & Services Administration 2022). We used participants' zip code to determine if they live in a rural or non-rural county based on FORHP classifications. Not all participants provided all demographic information; thus, categories do not add up to the total.
[a] Total sample size for age is 22 because age was not reported from four of the participants.
[b] Total sample size for FORHP classification is 22 because zip code was not reported from four of the participants.

Theme 1: Farmers' Experiences with Internet and Digital Technologies

Focus group participants described four distinct experiences with the internet and digital technology: the locations where they use the internet, the internet providers available to them, the types of computing devices they use to connect to the internet, and their ability to troubleshoot internet and computing technology issues.

Theme 1.1: Internet Use Locations

Participants reported using the internet daily, accessing it via cellular data or Wi-Fi networks at home and at work. For many participants who lived on their farm property, these are one and the same. For example, a Banks County farmer mentioned, "The hotspot is at our house, and the

Table 2. Survey Participants' Demographic Characteristics (*n* = 113)

Demographic characteristic	*n*	%
Gender		
Men	94	83.2
Women	19	16.8
Race		
White	104	92.0
Black/African American	7	6.2
Native American	2	1.8
Crop Produced/Livestock[a] Raised		
Soy	48	42.5
Corn	39	34.5
Beef	38	33.6
Wheat	31	27.4
Tobacco	26	23.0
	$\bar{x}$	*Sd*
Acreage Farmed	774.95	1,123.4

Note. All participants were ≥18 years of age.
[a] Participants could select multiple responses, so sample adds up to over 100%. Table only shows the top 5 most frequently reported crops produced/livestock raised from the survey results.

service is fine." Additionally, some participants shared that they use cellular data while driving (e.g., GPS) or running errands around town and that they travel to various public buildings (e.g., church, local McDonald's, public library) to access reliable Wi-Fi.

Theme 1.2: Available Internet Providers

All four counties had various options for internet service providers that provided cellular data and home and business internet. However, participants noted having limited options in what internet service provider they could choose due to coverage gaps in their areas. A Sanders County farmer stated,

> When I went into Verizon to purchase another cell phone as a hotspot for our business, I was sitting and discussing with the clerk, and she said, "Here at our Verizon store, Verizon doesn't even cover" because they have terrible service there.

Table 3. Survey Respondent Device and Troubleshooting Characteristics

Survey question	Total (113) % (*n*)
Computing device access	
Have own smartphone	95.6 (108)
Have own tablet†	61.6 (69)
Have own laptop	85.8 (97)
Social media use	
Facebook	72.6 (82)
GroupMe	5.3 (6)
Instagram	36.3 (41)
WhatsApp	13.3 (15)
Snapchat	28.3 (32)
TikTok	25.7 (29)
YouTube	70.8 (80)
Device/internet troubleshooting	
Can solve problems with device	35.4 (40)
Knows where to go for tech assistance	79.6 (90)
Afraid of using devices	5.3 (6)
Uses new technologies easily*	52.7 (59)
Tend to use familiar technologies*	52.7 (59)
Can solve problems with Internet	38.1 (43)

* Sporadic missingness for these variables resulted in a denominator of 112 for the calculation of the percentages.

Participants from all four focus groups stated they have tried multiple providers, but most do not meet the minimum needs of the user base. For example, a farmer reported, "I've tried dial-up. We've tried satellite dishes. None of them work well enough, really, when you start sending a lot of data" (Banks County).

Theme 1.3: Internet Accessible Computing Devices Used

Across all focus groups, participants mentioned cell phones as the main device they use to access the internet. Additional devices included laptops, tablets, smart TVs, credit card machines, and security cameras. A Crawford County participant shared how they own produce refrigerators that connect to the Internet: "Our refrigeration system for produce runs off Wi-Fi, so we can operate it off our phones and make sure the system hasn't shut down."

The pervasiveness of cell phones, laptops, and tablets among our focus group participants was consistent with our survey findings (Table 3), in which a majority of farmers reported owning smartphones (96%), laptops (86%), and tablets (62%).

Theme 1.4: Capacity to Troubleshoot Internet and Device Issues

Findings from focus groups and surveys revealed mixed results regarding farmers' ability to troubleshoot issues with the internet and devices, such as phones and computers, and their comfort level adopting new technologies. Some focus group participants shared that they try to fix technology and internet problems themselves, "I usually try to fix it myself. It's got to be really bad for me not to be able to fix it myself" (Reynolds County). Others shared that they reach out to family members (e.g., their children, niblings, spouse) or customer service for support. One explained, "You don't have to know everything. You just need to know people you can call" (Sanders County).

Less than half of the survey respondents (Table 3) reported knowing how to solve problems with their devices (35%) or their internet connection (38%), while a majority (80%) reported knowing how to ask for help with solving a problem

with their device or internet (Table 3). Additionally, half of the survey participants (Table 3) indicated that they adopt new technologies easily (52%).

Theme 2: Impacts of Digital Technology on Owners and Managers

Focus group participants shared various ways digital technology has positively and negatively impacted their work as farm owners and managers. Positive impacts included promoting their business, sharing industry information, and accessing agricultural apps; negative impacts included safety concerns, time burdens, and business and operational challenges.

Theme 2.1: Positive Impacts

One positive impact was the ability of farmers to establish an online presence to promote their businesses. One Sanders County farmer stated, "We primarily use Facebook for our business. We need that online presence." Farmers reported using a variety of social media sites, whether for professional or personal reasons. Survey results (Table 3) indicated that Facebook was the most popular platform among participants, utilized by over two-thirds (73%). At least a third of survey participants used Instagram (36%), with 28% reporting using Snapchat and 26% reporting using TikTok. Participants reported using social media to learn about other businesses with which they may want to interact; for example:

> I use social media, Instagram, Facebook kind of like a private detective. [When] I'm looking for something, I want to know before I go there if they are going to offer my service. Is it worth me driving 120 miles to do that? I need to know about the farm and what they're offering me. (Reynolds County)

Farmers' use of social media to promote their businesses helped some stay connected with their clients during the COVID-19 pandemic. A Crawford County farmer mentioned "keeping up with your clientele through social media and being able to advertise what's still going on on your farm, even with the pandemic, and still offering services and what you're selling just on a different setup."

Additional benefits mentioned include maintaining farm security, managing crop diseases, and using agriculture-based apps. A Crawford County farmer shared how they use the internet and digital cameras for security surveillance of their property: "I have cameras set up on my equipment, around my equipment, and I also use the internet on my trail cameras." Other participants described how digital technology helps farmers share information with industry professionals who can provide technical assistance and guidance. A Crawford County farmer explained,

> We've got what seems to be a disease problem for the soil; being able to take a picture of it on the phone and text it to our vendor helps him to identify what he's got to sell us to supply, whatever our crop is.

A few participants shared how agricultural apps have helped them with various farm-related needs. For example, another Crawford County farmer stated,

> There are a lot of agriculture apps we use for farming. One is called Picture This, which is a weed identifier if you can't identify the weed by common knowledge. Then, Farm Logs, they'll keep track of rainfall and planting dates and things like that.

Some participants described how access to the internet assists farmers with searching for information online and accessing continuing education, such as staying up-to-date with required training. Focus group participants reported relying on Google and YouTube to find information: "Whether I'm working on something and trying to figure something out with the tractor … maybe something's going on with what I'm planting … I try to research and kind of look between YouTube and Google" (Crawford County). Both our focus group and survey findings indicated that YouTube is widely used among farmers, with approximately 71% of survey participants reporting use (Table 3). While YouTube is classified as a social media site, our focus group findings suggest farmers utilize it as

a search engine: "We use a lot of YouTube to look up that stuff and try to fix your own equipment" (Banks County). In terms of pursuing continuing education, a Reynolds County farmer stated, "We have to stay on top of so many hours for our lagoon permit, and some of that is offered online. So, we're able to log in to keep us up-to-date."

Theme 2.2: Negative Impacts

Most of the impacts shared by participants focused on challenges they endure due to inadequate internet infrastructure in their communities. Four common negative impacts were poor internet quality, safety concerns, time burdens, and business and financial operation challenges.

Theme 2.2.1: Poor internet quality

The reliability and quality of internet service varied for participants and often depended on their location. Participants shared that Wi-Fi signals in their homes did not extend to their farm fields, so they relied on cellular data to complete internet-dependent tasks while out on the farm. However, several participants shared that even cellular data signals can be weak or nonexistent when out in the fields, leaving them with no internet access at all. One participant from Banks County described, "The other day, I was at a shrubbery farm, and I turned my phone on. I told my nephew it [the phone] actually laughed at me, didn't have anything [signal]." Participants reported consistently weak or unreliable internet connections with their Wi-Fi services; for example, "The Wi-Fi is pretty slow for your laptop." Some indicated that they limit the number of devices connected to the Wi-Fi router to use the internet, or reduce video stream quality to participate in online meetings, due to limited bandwidth. For example, a Banks County farmer explained,

> The hotspot is at our house, and the service is fine. I've tried using it a couple of times for Zoom with work. I just have to lower my video settings to the lowest possible resolution, and every device in our house has to be turned off except for my computer.

Theme 2.2.2: Safety concerns

Participants described how a lack of reliable internet has created safety issues. Several participants expressed concerns about trespassing and theft from their properties and the desire to install live-streaming security cameras; however, they reported being unable to follow through due to insufficient internet connectivity. For example, one farmer mentioned, "It would be nice to put your video cameras on it for security, but it's unreliable" (Banks County). One participant mentioned how unreliable internet adversely affects the quality of farm-related tasks, such as filing reports:

> I can't believe that we don't address it more. It should be a priority. It's dangerous for one. Farmers can't input reports like they should. Or they could, but they don't want to take the headache of driving somewhere to do it, so you don't get what you really need in reports. (Banks County)

In addition to the professional safety concerns shared, participants identified several personal safety concerns. A participant from Reynolds County mentioned how many farmers and other community residents have decided to get rid of their landlines at their houses and rely on Wi-Fi calling via their cell phones for communication. Participants described how their dependence on cell phones for communication becomes concerning and potentially dangerous when the internet service is slow or is not working properly. For example, one participant from Banks County mentioned her mother's inability to contact people for assistance (e.g., family members, emergency medical services), saying, "She depends on the [landline] phone because her cell phone doesn't work. Well, the AT&T [landline] phones go out constantly, and she has nothing, no phone, no internet, no telephone, no nothing. It's a safety issue." Also, insufficient access to high-quality internet was perceived to affect healthcare access in rural communities. As explained by a Banks County participant,

> Medicine is absolutely going tech. It's been going tech for years, but our patients [in this county] can't because they can't hook up to the

> internet. … Patients in rural communities are one hundred percent left behind in all the technology that's benefitting everybody else.

Theme 2.2.3: Time burdens

Farmers reported that inadequate internet connectivity has resulted in undue time burdens. Many participants mentioned that, due to the lack of internet connection, they had to print out physical copies of work documents to fill out initially and then spend extra time digitizing the information. A Reynolds County farmer stated,

> A lot of our documents, where we keep data sets, are cloud-based. If we are down at the barn taking yearly measurements on our cattle and wanting to input them into our Excel documents that are cloud-based, we can't do that down at the barn. We have to print off a hard copy at the house, write it down at the barn, and then go and enter all that data back in instead of doing it all at one time. That's a huge time-consuming thing, but we obviously can't work cattle up in the house.

Additionally, farmers reported having to spend extra time driving to a secondary location, such as their church or a McDonald's, to download or share documents (e.g., via email). A Banks County farmer mentioned, "I go to the church that I attend. We have high-speed internet and Wi-Fi there when I have to send and receive documents, download documents, and that kind of thing."

Theme 2.2.4: Business and financial operation challenges

Farmers reported that internet connectivity is insufficient to operate their businesses or modernize their business practices effectively. For example, a Sanders County farmer explained,

> At home, it works okay most of the time, but here [at my farm business], sometimes we're completing transactions through our system, it'll stall. It's kind of embarrassing with a customer when you've got to wait a second for the thing to catch up. I've been on the phone with Star on two occasions, and what we've determined is we have about one-third of the strength we need here to do what we need to do.

Farmers expressed a desire to purchase new equipment and labs for their farms but explained that they cannot do so due to insufficient internet access. A Reynolds County farmer shared,

> We do IVF embryo work on cattle at our facility, and down at the barn where we work the cows, we don't have Wi-Fi. It was going to be really expensive to get a second router down there. It'd be helpful for the technicians who do that work to have that. Some of the high-tech cattle equipment, vet equipment uses Wi-Fi and Internet. Being able to have a second hub on that farm, separate from the house where there's Wi-Fi, would be really good for us.

While farmers mentioned that having an online presence through websites was beneficial for their businesses, they also shared the challenges they experienced when attempting to create or update their websites. One challenge shared by participants was that the website loads slowly, making it hard for them to update the site. A farmer from Reynolds County shared, "We also would like to get into having a website for the cattle operation, but I probably unplug or restart our Wi-Fi once a day." In addition to the internet connectivity challenges with website development and maintenance, a lack of digital technology skills (such as website construction) was identified as an additional barrier farmers face in operating and modernizing their businesses. A Sanders County farmer described, "I would like to update my website. I would like to put movement and sound on several websites. … It's very costly, and I don't know those skills."

Farmers reported that the lack of sufficient internet access in their communities causes them to spend extra money. Participants described differences in financial situations and lifestyles between those with high-quality, reliable internet and those without. For example, one farmer in Banks County stated, "The rest of the world, they're not spending the money that we spend to

try to achieve things that we shouldn't have to. The internet cost is high that you get, we spend more money than a normal person." Another financial challenge experienced by farmers was lost revenue and profits due to equipment failures (such as animal feeders, water dispensers, and refrigerator systems for produce). Farmers shared that there is technology available that can monitor their equipment and help prevent financial losses through early detection, but many have not invested in it due to unreliable internet connections. One farmer from Reynolds County stated,

> There's a lot of areas that could be improved with raising chickens to put sensors on the feeders, the waterers, the curtains even. Being a mile and half down the road, there was a lot of feed that was destroyed or gone bad. There was a lot of things that could have helped if there would have been internet and communication back and forth to the house to let us know we've got a problem with the feeder in chicken house number four. Automation means a whole lot, I think.

Theme 3: Owners' and Managers' Sentiments Toward the Internet Infrastructure

Farmers' attitudes toward the internet infrastructure in their counties varied among focus groups. Those from Banks County expressed the most frustration with their area's current internet options and connectivity compared to other counties, with one Banks County farmer stating, "I mean, it doesn't matter where you're at. It's all terrible." They also voiced vexation over political decisions and, at times, the lack of action on investing in rural broadband. One Banks County farmer stated, "We're surrounded by a half million acres of [a] National Forest. The government has plenty of places to put towers, and I don't understand it. I mean, that's a priority with the politicians, but it's all talk, no action." A common sentiment among Banks County farmers was the urgency for addressing internet connectivity challenges: "We use, and we need it, but the most important thing is the urgency that you present this to people who can make something happen. … We need it, and we need it now." Farmers in Crawford County also expressed frustrations with their county's current state of internet connectivity. For example, one farmer said, "CenturyLink wasn't offered in my area where I am at, but everybody around me has. I had to go with satellite internet, and that sucks. It really sucks."

In Sanders County, farmers acknowledged that their internet needs were not being met; however, they also perceived that internet companies were doing their best, given the unique challenges of being located in a rural county. One participant shared,

> They're doing the best they can do with what they have. I know our local provider several years ago got a grant to help with rural infrastructure. I was speaking with someone just the other day, and they said they needed the grant money to help make it work because they would never get the return back.

One common sentiment among all the counties was the necessity of having high-quality, reliable internet access, "If the internet is down, it would be like cleaning your house when the water pump is down. You cannot clean your house. It stops you. Even when you're trying just to dust, you need water running" (Sanders County).

Discussion

In this mixed-methods study, we found that technology is an integral part of day-to-day business operations for NC farmers. Participants in our study emphasized that internet connectivity is critical for farms and that they need enhanced access now. They expressed an urgent need for better internet access for farms and agricultural communities across NC, resonating with a prior report of NC farms (NC Department of Information Technology, n.d.). Farmers in our study prioritized communication with other businesses and customers using social media and business websites; finding information online, particularly technical assistance and how-to videos; and technology-enhanced production and security practices. Our findings are consistent with other recent research conducted with direct market farmers, agritourism operators, and users of precision technology in agriculture

(Cui, 2014; D'Antoni et al., 2012; Hollas et al., 2022; Pesci et al., 2023, 2024).

Participants in our study were keenly aware that their access to markets and advanced production and security practices is limited by the lack of affordable, reliable internet and a paucity of options among internet service providers (ISPs). With adverse impacts on safety, time, and financial resources, inconsistent connectivity negatively affects the economic well-being of NC farmers, according to our study participants. Our findings indicate that inadequate internet access imposes real costs that can stymie the economic well-being of agricultural producers and communities. This is consistent with previous studies that highlighted the economic benefits of broadband access in agricultural communities. For example, LoPiccalo (2022) found that higher internet speeds can reduce farm operating costs and significantly increase crop yields, especially for corn and soybeans. Another study found a positive impact between download speeds and farmland sale prices, where a one megabit per second (Mbps) increase in download speed raised farmland sale prices by 0.27% (Qu et al., 2025); this finding is important for farmers who own their land, as farmland constitutes one of the biggest components of a farmer's financial assets and investments. The relationship between broadband access and the success of farm business operations can further be considered a determinant of health. In addition to improving economic mobility for the agricultural community through education and employment, internet access promotes health by connecting people with health information, health services, and digital health including telemedicine (Early & Hernandez, 2021; Graham et al., 224).

This study provides insight into NC farmers' digital skills and corresponding training needs. Approximately half of the survey respondents felt that they did not adapt well to new technologies, preferring to use familiar ones. Less than half of respondents felt they could troubleshoot their devices and resolve internet issues if they experienced them. As internet infrastructure improves in agricultural communities and advanced production practices (e.g., precision agriculture technologies, apps, and devices) become more accessible to a wide range of farmers, training will be needed to build digital skills and resilience. Prior research suggests that early adopters of new technology tend to have good access to information and perceive that the technology benefits their specific agro-climatic environment (Chavas & Nauges, 2020). Thus, in order for new technologies to be widely adopted as they become available, farmers must perceive a positive net benefit to consider learning and adopting technologies and must have access to appropriate information resources and channels.

This work amplifies and builds on existing recommendations for addressing internet connectivity infrastructure and the digital inclusion of farms and agricultural communities across NC. A convergence of research findings emphasizes the imperative need to improve data systems to identify farm locations that would benefit from internet connectivity, adopt and implement policies to reduce costs of building or upgrading infrastructure, and identify and implement "last-mile" solutions to provide internet connections in rural areas (NC Department of Information Technology, n.d.). Potential solutions include fiber-to-farm, fixed wireless, hotspot lending, and Cooperative Extension–led digital skills workshops that help farmers stay current with the latest advancements in digital technologies, such as artificial intelligence, big data, and precision agriculture (Cofie et al., 2022; Keerthi et al., 2025). Federal and state policymakers should also consider how farm locations are classified as broadband-serviceable locations for network infrastructure upgrades and how to improve data quality in state infrastructure planning maps.

Strengths and Limitations

There are strengths to this study, including its rich data collection in multiple counties across NC, rigorous qualitative analysis, and ability to share participant voices. However, there are also some limitations. Our data are specific to NC, its farming, and its policies related to digital inclusion. Thus, our findings may not be directly applicable to other states. The survey used convenience sampling at a widely attended farm show in the state capital of Raleigh. Thus, it does not necessarily represent people who did not attend, which could have an influence on the results. For example, the farmers

who attended the farm show could be more digitally connected or less digitally connected than those who did not attend. We did not collect the ages of survey participants, other than confirming they were 18 or older. This precludes our ability to look for differences by age. We suggest that future research collect and compare responses by age to examine how farmers' age affects digital literacy and resilience.

The focus groups for each county also utilized convenience sampling, and the findings could be biased toward farmers who are more engaged with Cooperative Extension or have stronger opinions about connectivity. However, the focus groups were often organized around other events and thus did not only include people who had strong opinions about internet access. Lastly, most of the participants in the study were white men (and older, in the case of survey respondents), and different challenges or barriers could emerge with greater participation among women and greater diversity in racial and ethnic identities. However, despite this and our use of a convenience sample, the demographics of our participants do generally reflect the older, whiter, and more male demographics of NC producers according to the 2022 U.S. Census of Agriculture (USDA, 2024).

Future research should consider the experiences of women and those with other racial and ethnic identities, comparative studies where different policies or grant programs are being implemented, and how other rural populations might support our findings or reveal alternative themes. For example, rural schools and hospitals may face similar infrastructure and skills challenges, but individuals working in these settings could offer different perspectives from the farmers in our study. Further insights may also be gained by studying "leapfrogging" technology from lower-resource settings and exploring potential next-generation infrastructure, including emerging technological solutions for internet infrastructure on farms.

Conclusions

Internet access on many NC farms is not sufficient to support modern farming needs and may hinder economic development in agricultural communities. Farmers in NC have a range of digital skills and resiliency, with about half of the participants reporting that they can use new technologies easily. In discussions about the use of technology on farms, a lack of reliable, affordable internet access remains perhaps the biggest issue for the NC farmers in our study. Broadband infrastructure efforts and alternative options for remote areas should ensure that farmers and agricultural communities are included in planning and implementation.

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Building protective data infrastructure for urban community gardens: Lessons from the Philadelphia Garden Data Collaborative

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Abstract

Across U.S. cities, community gardens embody a conundrum: they are vital to community well-being and integral to urban social infrastructure, yet they are also profoundly vulnerable due to insecure land tenure, fragmented policy support, and systemic disinvestment. This reflective essay examines how garden data infrastructure can shape both sides of this conundrum, strengthening gardens' contributions to community life while also heightening their vulnerability to land loss. We focus on the case of the Philadelphia Garden Data Collaborative (PGDC), a multistakeholder initiative dedicated to documenting, protecting, and advocating for community-managed green space in Philadelphia. As participant researchers, we trace the evolution of PGDC's efforts from grassroots mapping to the development of coordinated data stewardship, and we explore how these efforts have enabled both emergency interventions (such as preventing sheriff sale evictions) and long-term preservation strategies. We examine the ethical dilemmas involved in collecting and using sensitive community data in a

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context where bureaucratic neglect has historically rendered gardens invisible, and where increased visibility can expose them to new forms of risk. While data can strengthen advocacy and inform policy, it must be coupled with secure tenure mechanisms and sustained public investment to ensure the future of urban gardens.

Keywords
community gardens, urban agriculture, land insecurity, data governance, data infrastructure, Philadelphia

Introduction

Food insecurity affects over 47 million Americans, with urban residents facing particular challenges accessing fresh, affordable food (Rabbitt et al., 2024). Community gardens have emerged as important community responses to these gaps, offering not just sustenance but spaces for connection and self-determination. Vital to urban communities, yet often in an unceasing state of precarity, urban community gardens flourish in the margins. Tucked into vacant lots, nestled between houses, or sprawling across post-industrial land, these spaces provide critical services that cities often struggle to deliver. They are sites of resistance and resilience, where communities assert their right to the city and invest in their neighborhoods on their own terms. They are classrooms where children learn where food comes from, kitchens where cultural traditions are preserved through heritage crops, pharmacies where medicinal herbs provide healing, and town squares where neighbors become family.

Despite their layered contributions to urban health and well-being, community gardens are precarious forms of land use in U.S. cities. Many lack formal tenure or legal protection, existing through informal arrangements or the sustained use of vacant land. Even the threat of loss can have detrimental effects. For many gardeners, the work of building and nurturing a garden is undertaken with an awareness of the garden's fragility. The possibility of destruction influences decisions about what to invest in, as gardeners may hesitate to build structures or commit to long-term plants like fruit trees or other perennials when their space's future is uncertain. As urban land values rise and planning priorities shift, gardens can vanish with little warning, bulldozed for new development, fenced off for infrastructure projects, or erased by neglect.

Consequently, when a garden is lost, it can tear at the social and ecological fabric. The loss of a garden is rarely just the loss of green space. It often signals the collapse of a complex web of social and ecological relationships that took years to build. What is lost is not only what can be seen, but what has been cultivated and shared: soils built through care, plants tended across seasons, and the gatherings that weave communities and give these spaces meaning. In such respects, gardens contribute a form of world-making that defies the alienation, brutalism, and toxicity that otherwise pervade modern urban life.

Preserving garden spaces requires more than good intentions; it demands systematic documentation, strategic analysis, and coordinated action. Preservation efforts, however, can be reactive and fragmented without comprehensive data about where gardens are located, who tends them, what threats they face, and what support they need. Yet data collection itself carries risks: making gardens visible can expose them to speculation and displacement. Navigating this tension is at the heart of the work described in this paper.

This paper draws on the experience of the Philadelphia Garden Data Collaborative (PGDC), a partnership of academics, advocates, and community organizations formed in 2014 to address this challenge. Through collaborative processes, PGDC has created a database that is a geospatial record linking community gardens to the tax parcels on which they sit. This parcel-level structure allows garden data to be cross-referenced with city property records, ownership information, and zoning designations. The database tracks garden locations, boundaries, organizational status, land tenure arrangements, and vulnerability indicators. The information is compiled through partner organization records, field surveys, and historical documentation over more than a decade. The rationale for garden data collection ultimately rests on a simple premise: what is not counted does not count in policy decisions and in the public eye. We begin by examining why gardens matter as urban infrastruc-

ture and why comprehensive data about them has remained elusive. We then turn to the ethical tensions inherent in documenting vulnerable spaces; while data provides a way to put gardens on the map, being on the map can also put gardens at risk. We describe how PGDC has sought to balance the need for visibility with the imperative of protection. Finally, we trace PGDC's evolution from grassroots documentation to active intervention, including a sheriff-sale monitoring system designed to detect when garden parcels are going up for municipal auction. Throughout, we argue that data infrastructure, when developed in partnership with communities and grounded in principles of care and accountability, can serve as a tool for preservation rather than displacement.

Gardens as Essential Urban Infrastructure

Community gardens in Philadelphia function as critical urban infrastructure, though they are rarely recognized as such in city planning documents or budget allocations. In many urban redevelopment models, particularly those shaped by neoliberal policy, land is assessed primarily in terms of its potential to attract investment and generate tax revenue. Within this framework, community gardens are often viewed as inefficient uses of space, especially when compared to commercial or residential developments that promise higher fiscal returns (Drake & Lawson, 2014; Lawson, 2007). Yet this narrow economic calculus overlooks the multifaceted contributions of community gardens, ranging from food production and public health to environmental resilience and social cohesion. Many of these contributions are essential to urban well-being, similar to other municipal public goods like roads, pipes, and power lines, even if they are difficult to monetize or quantify.

Understanding and documenting these multifaceted benefits is crucial for making the case for garden preservation. The most self-evident contribution of community gardens is to food security. Hunger and food insecurity are trenchant problems in major U.S. cities that are riddled by economic inequality. Unequal food access profoundly shapes Philadelphia's urban geography. Roughly 275,000 Philadelphia residents (17.6%) experienced food insecurity in 2023. In such contexts, community gardens serve as critical infrastructure for food security and public health (Feeding America, 2025; Santos, 2024). The Pennsylvania Horticultural Society's City Harvest program provides seedlings and other inputs to community gardens in exchange for the gardens donating a portion of their harvests to local food pantries or sharing crops with their community (Pennsylvania Horticultural Society, n.d.). Beyond food quantity, gardens also contribute to food sovereignty, empowering communities to control their own foodways. This includes offering culturally appropriate foods often unavailable in conventional markets—from Mexican epazote and Caribbean callaloo to Asian bitter melons—thereby enabling immigrant and ethnically diverse communities to maintain food traditions essential to their health and identity (Hynes, 1996; Vitiello & Nairn, 2009).

Gardens also contribute to environmental health. In cities like Philadelphia, dominated by impervious surface cover, community gardens provide rare and valuable pockets of greenspace. These spaces generate numerous co-benefits that foster environmental resilience and urban biodiversity. Unlike impervious surfaces, gardens offer permeable soil and vegetation that allow rainwater to infiltrate on-site, which decreases the volume and velocity of runoff entering municipal stormwater systems and mitigates flooding (Gittleman et al., 2017). The water quality benefits are real but not unconditional; compost-amended soils can leach phosphorus over time depending on amendment type and management history (Small et al., 2024). This is especially critical for cities with aging combined sewer systems like Philadelphia (Philadelphia Water Department, 2011, 2020). Gardens also mitigate urban heat island effects, improve air quality, and sequester carbon (Lovell, 2010; Lovell & Taylor, 2013). Additionally, community gardens help mitigate ecological fragmentation, creating small but critical nodes of connectivity for urban biodiversity and supporting more continuous ecological networks across the city (Di Pietro et al., 2018). Without comprehensive data on garden locations and characteristics, however, the city cannot fully account for these ecological contributions in climate planning.

Perhaps most importantly, gardens serve as social infrastructure, the places where community bonds form and strengthen (Klinenberg, 2018). In neighborhoods fractured by disinvestment, racial and economic inequalities, violence, and displacement, gardens create empowering spaces where neighbors become collaborators. Philadelphia offers vivid examples of this dynamic. Las Parcelas, a community garden in the Norris Square neighborhood, has served as vital social infrastructure since the 1980s, when neighbors transformed vacant lots into a space for cultural expression, intergenerational knowledge-sharing, and community empowerment (O'Brien, 2023). Heritage crops, murals celebrating Latin identity, and culturally significant gathering spaces like "La Casita" reflect the garden's role not just as a place to grow food, but as a site of collective identity and care (Hynes, 1996; Jaramillo, 2017; O'Brien, 2023). Across the city, many gardens host cultural celebrations, youth programs, senior activities, and informal gatherings that weave the social fabric. This social connectivity proves especially vital during crises, as demonstrated during COVID-19 when gardens became lifelines for food access and mental health support (Curlin, 2022; Falkowski et al., 2022; Jaramillo, 2020). In Philadelphia, this response was swift and tangible: the city designated community gardens as essential services within days of the initial lockdown orders, allowing gardeners to continue tending their plots when most public spaces were closed (Jaramillo, 2020). As the pandemic wore on, participation surged across the city, with gardens absorbing heightened demand for fresh food, outdoor space, and community connection at a moment when formal institutions struggled to respond at the same speed (Curlin, 2022).

Taken together, these various facets of community gardens make them crucial sites within a wider urban solidarity economy that extends beyond urban agriculture alone (Safri et al., 2025). By prioritizing shared land stewardship, cooperation, and community-defined value, gardens offer tangible examples of how land, labor, and resources can be organized around sustainability and collective well-being rather than the profit motive (Colding & Barthel, 2013; Ostrom, 1990). With this, they create space to practice and imagine economic relations beyond capitalism.

The Data Gap Challenge

Despite these multifaceted benefits, Philadelphia's community gardens have historically existed in an information vacuum, where efforts to collect data on gardens over time have been fragmented at best. By "data" we mean the systematic documentation of gardens as places: their locations, boundaries, land tenure arrangements, organizational status, and the social and ecological conditions that shape their vulnerability and value. This data gap has serious consequences for garden preservation and support. Without reliable records, preservation opportunities are frequently missed, as advocates are unable to mobilize in time to protect gardens that are threatened. Support organizations struggle to allocate limited resources efficiently, often working reactively rather than strategically. In the absence of aggregated data, advocates also face challenges in making strong policy arguments, as they lack the evidence needed to demonstrate the collective impact of gardens across the city. This data gap can also disempower community members by limiting their ability to connect with other gardeners, access available resources, or learn from shared experiences. As a result, the same patterns of displacement and loss continue to occur, with lessons going undocumented and unaddressed. The Philadelphia Garden Data Collaborative (PGDC), the subject of this paper, emerged directly in response to this gap.

This is not to suggest that there have been no efforts to collect garden data. Since the 1890s, various organizations have attempted to document Philadelphia's gardens, but these efforts remained isolated and incomplete. The Philadelphia Vacant Lots Cultivation Association kept records on vacant land use cases, including gardening, from 1897 until 1927 (Drake & Lawson, 2014). Victory Garden programs squeezed gardens into any available open space during the World Wars; some were documented, but many were not (Lawson, 2005). Penn State Extension counted gardens during the federal Urban Gardening Program (1977–1996), but those efforts wound down once federal funding was cut (Hynes, 1996; Vitiello & Nairn, 2009).

More recently, the Pennsylvania Horticultural Society and Neighborhood Gardens Trust have maintained lists of gardens receiving their support, but they account for only a fraction of all active gardens in the city. Until now, no mechanism has existed to systematically and comprehensively compile, update, and share garden information.

Unlike cities such as Seattle with its P-Patch program, Philadelphia has no dedicated municipal office responsible for community gardens (Kaufman & Bailkey, 2000). Historically, community gardens in Philadelphia have instead relied heavily on support from nonprofit organizations, many of which are funded by philanthropic donors whose priorities can shift over time, leaving gardens vulnerable to changing interests and funding landscapes beyond their control (Vitiello, 2022). The city of Philadelphia only recently began investing in urban agriculture, appointing its first-ever urban agriculture director in the department of parks and recreation in 2019 to develop a citywide plan. The novelty of these developments belies the historically limited municipal capacity dedicated to supporting urban agriculture generally and community gardens in particular (Jaramillo, 2019). Many gardens are nonetheless located on city land. That land falls under multiple city departments (parks and recreation, the water department, public properties, the redevelopment authority, the land bank) with no clear coordination mechanism. This bureaucratic patchwork has meant that no single municipal entity knows how many gardens exist, where they are located, or what support they need. As such, when planning and development decisions are made, it is difficult to advocate for garden interests.

The fragmented character of garden data collection has been compounded by the ephemeral nature of many community gardens, which presents significant challenges to tracking and documentation. New gardens emerge each growing season as communities claim vacant land. Some evolve in form or function over time, while others go dormant during difficult years but may revive with new leadership. Keeping garden information updated is challenging, and without recurrent documentation, this dynamism becomes invisible. Gardens can exist for decades serving hundreds of families, and yet leave no official trace when threatened with development (Drake & Lawson, 2014). The flexible structure of gardens enables them to evolve in response to changing community needs, thereby enabling adaptation, experimentation, and local control (Kremer & Hamstead, 2015). This same quality makes them difficult to formally account for in conventional datasets. Nonetheless, the complexities of documentation should not be seen as a deterrent but rather as an essential step toward fuller recognition of gardens and their values for communities.

It was in response to this persistent data gap that the Philadelphia Garden Data Collaborative emerged. In 2014, academics, advocates, and representatives from garden support organizations came together, recognizing that despite Philadelphia's rich tradition of urban agriculture, no comprehensive database existed to track and protect these vital community resources. Initial partners included researchers from Haverford College and Villanova University; the Public Interest Law Center, which provides free legal representation for threatened gardens through its Garden Justice Legal Initiative (Public Interest Law Center, n.d.); the Neighborhood Gardens Trust, focused on permanent land preservation of community-managed green space (Neighborhood Gardens Trust, n.d.); the Pennsylvania Horticultural Society, with decades of garden support and gardener relationships (Pennsylvania Horticultural Society, 2022); and Soil Generation, a Black- and Brown-led land and food sovereignty collective that has helped ensure the inclusion of community voice in data governance (Soil Generation, n.d.). The collaborative set out to build a geospatial database that could systematically document garden locations, parcel ownership, and land tenure status across the city. The catalyst for collaboration came from witnessing repeated garden losses to real estate development and abandonment, and realizing that without systematic documentation, preservation efforts would remain perpetually reactive, always arriving too late to save threatened gardens. Yet from the outset, members also understood that documentation itself posed risks, a tension that would shape PGDC's approach from its earliest days.

A note on our positionality and approach: Kremer and Borowiak have been active members of the PGDC since its formation, participating in meetings, field campaigns, database development, and partnership decisions over the past decade. Scolio contributes as a graduate researcher engaged in ongoing PGDC data management and analysis. The reflections that follow draw on this sustained participation, on shared meeting records and internal documents, and on continuing dialogue with gardeners and PGDC partners. We write as engaged participants rather than external observers, and our account emphasizes the collaborative's internal reasoning and evolution.

Data as Double-Edged Sword: Risks and Protections

The decision to create comprehensive garden documentation was never straightforward. The collaborative's formation was shaped by a fundamental tension: gardens need visibility to access resources and protection, yet visibility itself can accelerate displacement. This double bind reflects what scholars of data feminism call "the paradox of exposure," where those who stand to gain most from being counted face the greatest danger from that same act of counting (D'Ignazio & Klein, 2020, p. 105). From the outset, the collaborative has had to navigate this tension carefully, weighing the benefits of visibility against its risks, and doing so in ways that earn and sustain the trust of the community growers it serves.

Currently, many of Philadelphia's community gardens exist on land the gardeners do not legally own. Some operate through handshake agreements with absentee landowners. Others simply cultivate abandoned lots, transforming blight into beauty without formal permission. PGDC estimates that nearly two-thirds (61.7%) of the land parcels on which gardens are located can be considered insecure (Borowiak & Kremer, 2025). This access to land enables communities to claim and improve neglected spaces, but it also makes gardens vulnerable to sudden displacement when property values rise or development interest emerges.

For many gardens on public land, land precarity is largely a consequence of bureaucratic neglect, where fragmented policies and inconsistent support have left these vital community spaces vulnerable to displacement. For decades, gardeners' access to public land was governed mainly by year-to-year agreements with the Philadelphia Redevelopment Authority: revocable licenses that granted temporary permission but no property right or land security (Cahn, 2015; Vitiello & Nairn, 2009). By the late 2000s, the agency had lost institutional memory of these agreements (Vitiello, 2022), and although revised city policies in 2012 allowed leases of up to five years for community gardens, the one-year revocable license remained the default and few longer leases were ever signed (Cahn, 2015).

In 2013, the creation of the Philadelphia Land Bank through legislation was heralded as a vehicle to streamline land disposition and preserve public-benefitting uses, including urban agriculture (Cahn, 2015; Public Interest Law Center, 2016). The legislation also includes provisions that enable the Land Bank to make priority bids on sheriff sale properties before they go up for public auction and to then transfer those properties to garden-preserving trustees. However, the Land Bank's performance has often fallen short: transfers to gardens have been few, application processes are opaque and slow, and since 2020 gardens have been required to accept 30-year self-amortizing mortgages linked to the appraised market value—an arrangement that places administrative and financial burden on small nonprofits (Schmidt, 2023a).

The absence of reliable data has contributed to this neglect by limiting public awareness about the true extent and significance of community gardens in Philadelphia. However, PGDC members have repeatedly heard community concerns that publicly documenting gardens could make them easier targets for speculation, a fear grounded in the experience of gardeners in fast-developing neighborhoods where developers have moved to acquire cultivated lots before the communities tending them could secure ownership (Laughlin & De Moya Correa, 2020). A thriving garden on an abandoned lot signals that a neighborhood has turned a corner, making it attractive for investment that rarely benefits existing residents (Safri et al., 2025). Especially in low-income neighborhoods of color that have endured decades of racialized disinvest-

ment, municipal betrayal, and organized abandonment, along with extractive relations from local universities, deep wells of distrust have accumulated over generations.

Recognizing these risks, PGDC developed stringent data protection protocols from its inception. This approach is informed by the concept of ethnographic refusal, as articulated by Audra Simpson (2014), which argues that not all knowledge should be made available for circulation, especially when sharing that knowledge may serve institutional or extractive interests rather than the communities it describes. Simpson frames refusal not as a withholding of knowledge, but as an assertion of sovereignty and care by refusing to reproduce harm through the mechanisms of documentation and disclosure. In that spirit, PGDC treats garden data not as neutral or public information, but as sensitive, community-generated knowledge requiring careful, relational stewardship.

A particular ethical challenge stems from how the database developed. Garden data was compiled over years from multiple sources, including partner organization lists, field surveys, and historical records. Given the informal nature of many gardens and frequent leadership transitions, obtaining retroactive consent from a representative of every garden is practically impossible. Some gardens in the database may not even know they are included. Because gardens often lack formal governance structures or continuity in leadership, there is often no clear individual or entity from whom to seek consent, making truly informed retroactive consent not just difficult, but in many cases unattainable. This creates an ongoing tension between the collective benefit of comprehensive data and individual gardens' right to control their information.

Key protective measures were implemented to enact a cautious approach. Unlike open data initiatives in other cities, PGDC maintains no publicly searchable database of garden locations. Data access is restricted to verified partners with a demonstrated commitment to garden preservation. Data governance within PGDC is structured around two tiers of memoranda of understanding. An internal MOU governs data-sharing and management among PGDC member organizations. External parties, including researchers, garden support organizations, and others, may apply for access through a separate external MOU process, which requires demonstrated alignment with garden preservation goals and includes explicit provisions against uses detrimental to gardens.

The collaborative continually navigates the balance between data protection and data utility. Excessive restriction would render the database useless for advocacy and resource allocation. Yet insufficient protection could transform a preservation tool into a displacement accelerator. This balance manifests in specific decisions about data granularity, access protocols, and sharing agreements. For instance, aggregated data at the census tract level can demonstrate garden concentrations and need without revealing specific locations. Heat maps can show development pressure without pinpointing individual gardens. These approaches enable policy advocacy while maintaining operational security for vulnerable sites. Access is tiered accordingly: aggregated and anonymized data may be shared more broadly for planning and advocacy purposes, while parcel-level location data identifying specific gardens is reserved for vetted partners with an active MOU and a demonstrated preservation mission.

Garden documentation data and supporting infrastructure transform advocacy from anecdotal appeals to evidence-based arguments. When the city proposes selling garden land, advocates can demonstrate exactly how many families depend on that space, what social and ecological benefits it provides, and how its loss would impact the neighborhood (Cahn & Segal, 2016). Data showing that 72.8% of gardens in predominantly Black neighborhoods lack secure tenure compared to 53.1% in predominantly white neighborhoods provide clear evidence of inequity that requires a policy response (Borowiak & Kremer, 2025). By illuminating these patterns, such data equip advocates to make targeted policy demands that address not only garden preservation but also the racial injustices embedded in urban land governance.

By creating comprehensive, accessible, regularly updated information about Philadelphia's gardens, the PGDC ensures these vital community spaces can no longer be ignored, forgotten, or erased without consequence. Data becomes a tool

for visibility, recognition, and ultimately, the preservation of community self-determination through urban agriculture.

From Documentation to Intervention

For the first several years after its inception in 2014, PGDC operated largely through volunteer effort, compiling data from partner organizations, conducting field surveys, and building relationships with gardeners, many of whom were justifiably wary of outsiders documenting their spaces. The collaborative's initial database of 470 gardens demonstrated both the scope of Philadelphia's urban agriculture and the threats it faced. A turning point came in 2023 with Philadelphia's development of its first Urban Agriculture Strategic Plan (Philadelphia Parks and Recreation, 2023). City officials recognized PGDC as the authoritative source for garden data, incorporating the collaborative's findings into official planning documents. As recognized in the plan, such data is crucial for assessing urban agriculture's value for the city, tracking community needs, identifying at-risk gardens, and preventing the accidental sale of garden land. For instance, PGDC's work revealed persistent patterns of garden loss, identifying more than 140 former gardens that had become inactive since 2008, with losses concentrated in low-income neighborhoods of color, many of which subsequently gentrified (Philadelphia Parks and Recreation, 2023, p. 50; Vitiello, 2022). This evidence transformed abstract concerns about displacement into concrete data that advocates could use in policy arguments. The plan's land recommendations direct the city to cross-reference PGDC's dataset against inventories of tax-delinquent property so that active gardens are not sold at sheriff sale, to support and help fund the collaborative's work, and to use PGDC data in land use planning, each with the assurance that garden data shared with the city remains internal and is used only for planning and preservation purposes (Philadelphia Parks and Recreation, 2023, pp. 54, 56).

The year 2024 marked a fundamental shift in PGDC's approach and capacity. The collaborative developed systematic data collection protocols using ESRI Survey123 and other digital tools, creating standardized forms for recording garden characteristics, boundaries, activity status, and threats. These protocols ensured consistency across multiple data collectors and established clear criteria for categorizing gardens by type, security status, and vulnerability indicators.

Building on these new tools, PGDC undertook its most comprehensive field data collection campaign to date. Over the summer of 2024, trained teams systematically visited over 700 known garden sites across Philadelphia, ground-truthing existing data and documenting new gardens. Because each garden in the database is linked to one or more tax parcels, the data can be cross-referenced against property records and tax status, making proactive threat monitoring possible. The updated database now documents 556 gardens across 1,421 parcels, which represents a level of completeness and accuracy that means the database can be fully operationalized in practice. This milestone is the result of years of painstaking work: merging disparate datasets, developing shared protocols, conducting field surveys, and building trust across a diverse network of gardeners and support organizations.

Having parcel-level data opened new possibilities for intervention. With comprehensive data, preservation efforts can shift from reactive to proactive. Most significantly, it enabled PGDC to develop a monitoring system for sheriff sales in 2024 that cross-references garden locations against properties heading to public auction, which enables immediate intervention when gardens face an acute threat of sale. The sheriff sale challenge, and PGDC's response to it, illustrates what becomes possible when comprehensive data infrastructure is in place.

The Sheriff Sale Challenge: A Case Study in Data-Driven Intervention

Philadelphia's sheriff sale system represents one of the most acute threats to community gardens, operating through multiple mechanisms that combine historical injustices, routine tax delinquency, and bureaucratic dysfunction. This crisis and PGDC's response highlights both the urgency of comprehensive garden data and their power to prevent displacement.

In brief, sheriff sales are public auctions executed by the Philadelphia Sheriff's Office in which

properties are sold to satisfy unpaid debts, most commonly delinquent property taxes or defaulted mortgages. They are distinct from the disposition of surplus public land, which follows separate processes through the Philadelphia Land Bank and the Philadelphia Housing Development Corporation (PHDC). Gardens face sheriff sale threats through several pathways. The land on which a garden sits may be sold because its owner has failed to pay property taxes over a number of years, or because the owner has defaulted on a mortgage. In some cases, gardens are located on parcels encumbered by old tax liens now held by private investors who initiate sales to recoup their claims. Regardless of the pathway, the sheriff sale process treats garden land no differently than vacant lots, prioritizing the highest bidder over community value (Philadelphia Sheriff's Office, 2021).

A particular subset of threatened properties stems from Philadelphia's disastrous 1997 tax lien sale. A tax lien is a legal claim a government places on a property when the owner owes back taxes; such liens can be pooled and used to back debt instruments (i.e., bonds) that are sold to investors and repaid as the liens are collected. Facing a school funding crisis, the city sold approximately 33,000 tax liens to private investors through a securitization deal with U.S. Bank (Hayllar, 1997; Melamed, 2021). The deal raised US$72 million in immediate revenue, but the city ultimately defaulted on over US$40 million of the bonds by 2004 (Melamed, 2021; Vargas, 2015). Rather than transferring property ownership, the original sale gave private entities long-term control over the liens, allowing them to initiate sheriff sales on tax-delinquent properties, many of which were informally stewarded community gardens or side yards. Properties encumbered by these liens became nearly impossible for communities to purchase, disproportionately impacting low-income, Black, and Latinx neighborhoods where residents had transformed vacant land without legal tenure. By 2023, approximately 2,000 properties remained affected, with U.S. Bank accelerating sales (Conde, 2023). Sustained advocacy by a grassroots network of community gardeners and allies, some of whom made use of PGDC data to identify at-risk gardens, resulted in the city purchasing US$1.1 million in liens covering 91 garden parcels in an effort to prevent displacement (Goodin-Smith, 2022; Schmidt, 2023b), which enables the Philadelphia Land Bank to exercise its power to acquire these properties at sheriff sale.

While land security has been won for some gardens, many parcels outside of the negotiated U.S. Bank lien settlement remain entrapped in the sheriff sale system, which disproportionately threatens gardens in marginalized communities. Analysis shows that 90% of properties sold since July 2019 were located in neighborhoods near or below the poverty line (Griffin, 2021). The structure of the process creates multiple barriers to community participation: minimal public notice, compressed timelines, online auctions favoring those with ready capital, and cash requirements impossible for most community groups. As a result, the city's land disposition system tends to privilege well-resourced developers while making it exceedingly difficult for communities to retain control of local land.

Recognizing that sheriff sales could erase decades of community cultivation overnight, PGDC developed an emergency monitoring protocol in 2024. Every week, members review sheriff sale listings two months in advance, systematically checking addresses against the garden database. When matches are found, PGDC members are notified and activate their networks. First, affected gardeners are identified and notified. Depending on the specific situation, gardeners are connected with resources to help them devise the next steps, whether that means legal support, alerts to city council members, or coordination with potential funding sources. The results demonstrate the power of systematic monitoring combined with organized response. Since implementation, over 20 garden parcels heading to sheriff sale have been identified, and through coordinated intervention, not a single one was sold.

The sheriff sale monitoring system exemplifies PGDC's evolution from documenting loss to preventing it. The gardens saved so far stand as proof of what is possible when data serve community preservation. Yet, with hundreds of properties still vulnerable, earlier intervention strategies are urgently needed. While celebrating these victories,

PGDC recognizes that emergency interventions cannot substitute for systemic reform. Garden preservation remains an ongoing struggle despite growing systems-level preparedness. The sheriff sale challenge teaches several critical lessons. First, comprehensive monitoring is essential: gardens face various pathways to loss, each with its own legal, historical, and relational dimensions that require different intervention strategies. Only systematic tracking can catch all threats. Second, timing matters. The compressed timeline of sheriff sales means that early warning systems are essential; by the time a sale is publicly announced, organizing effective resistance is often too late. Third, coordination saves gardens. No single organization can address the crisis alone; success requires gardeners, lawyers, politicians, and data providers working in concert. Finally, legal and technical fixes alone cannot solve political problems. As we saw in the case of the Land Bank, which has the legal tools to protect gardens but has nonetheless been stalled by bureaucratic disputes, good policy requires good execution. And that often requires the mobilization of communities and information in defense of gardens as vital community assets.

Reflections and Future Directions

Despite progress, enormous challenges remain for Philadelphia's gardening communities. With only 38.3% of gardens secure and development pressure intensifying, the race between preservation and displacement continues (Borowiak & Kremer, 2025). Analysis of garden loss patterns reveals two distinct threat profiles: gardens facing development pressure concentrated in gentrifying neighborhoods where land values are rising, and gardens vulnerable to closure due to disinvestment and capacity challenges. The latter account for roughly half of recent losses, pointing to the need for capacity-building investments alongside land preservation strategies (Fryberger, 2025). The PGDC is currently designing an interactive online data platform to give the city's urban agriculture community secure access to data that can help them advocate for their gardens. While this platform promises enhanced capacity, it cannot substitute for political will, resource allocation, and recognition of gardens as permanent community assets rather than temporary land uses.

PGDC's evolution demonstrates the need to reconceptualize both data systems and gardens themselves as essential urban infrastructure not only for their material functions, but for the alternative social relations they cultivate. Like water systems or transportation networks, comprehensive garden data enables coordinated action, efficient resource allocation, and crisis response. Gardens also operate within a solidarity economy, offering spaces of mutual aid, ecological stewardship, and collective care that contrast sharply with the extractive logics of mainstream urban development (Safri et al., 2025). These are prefigurative spaces where communities enact the kinds of reciprocal, sustainable relationships they wish to see more broadly. In this context, data become not merely a management tool but also a means of protection. Robust, ethically stewarded data systems can shield fragile commons from displacement, assert their value in policy debates, and build the evidentiary base needed to expand support. Just as cities invest in infrastructure to sustain economic growth, they must also invest in the infrastructures of care that community gardens represent.

By treating data as belonging to the documented communities, the collaborative's approach offers a model for ethical data partnerships in an era of surveillance capitalism and extractive research practices. Rather than positioning data as neutral or universally accessible resources, the PGDC recognizes data as socially situated and subject to the political realities of land insecurity, racialized dispossession, and uneven infrastructural support. Key principles emerging from PGDC's work include working to develop processes through which communities can exercise agency over access and use of their garden data, designing technical systems to support on-the-ground organizing rather than supplant it, securing multi-institutional and community-based support for long-term sustainability, and valuing incremental gains that lay groundwork for deeper, systemic change. This model challenges the dominant paradigms of open data and academic authority by foregrounding accountability to community-defined goals and by reimagining data as a tool for

collective liberation rather than commodification and state surveillance.

The PGDC's approach shares important principles with data sovereignty and data feminism scholarship. In particular, it shares the insistence that data collection serve rather than extract from the communities it describes, and that data stewardship respect those communities' agency over data that originates with them (D'Ignazio & Klein, 2020; Kukutai & Taylor, 2016; Walter et al., 2020). Yet the governance challenges facing urban community gardens are distinct from the Indigenous data sovereignty contexts in which much of this literature is grounded. Data sovereignty, as developed in that body of work, is rooted in Indigenous peoples' rights to self-determination over data pertaining to their nations, territories, and ways of life (Carroll et al., 2021). Applying this framework directly to community garden data risks overstating the parallel and importing assumptions that do not map cleanly onto this context. A fuller theoretical engagement with these connections, and the development of a framework better suited to community-controlled data in urban land governance contexts, remain important future work.

While Philadelphia's context is specific, lessons translate to other cities grappling with urban agriculture preservation. Many urban agriculture initiatives across the U.S. contend with similarly fragmented institutional landscapes, where responsibility for land management, public health, and planning is diffused across siloed agencies. Passive documentation must evolve to active intervention capacity. Data infrastructures must be designed not just to observe or record, but to intervene: to trigger alerts, inform legal action, and support policy change in real time. Community trust, built over years through transparency, reciprocity, and protection, can be destroyed in moments through careless data handling. This data enables a shift from reactive emergency response to proactive advocacy, equipping stakeholders to intervene before displacement occurs. However, realizing this potential requires reimagining the architecture of urban data systems to embed community control, care, and accountability at their core.

Conclusion

Community gardens in Philadelphia are living systems of care, stewardship, and resistance, yet they remain persistently vulnerable due to systemic neglect, fragmented policies, and inequitable access to land security. As this paper has shown, the absence of coordinated, comprehensive data has historically enabled the erasure of these spaces from planning processes and public discourse. PGDC emerged in direct response to this gap, building a careful, consent-based infrastructure to document and protect community gardens. Grounded in community partnerships and careful data governance, PGDC's approach demonstrates the power of grassroots data systems to not only document loss but also actively shape proactive preservation strategies. This effort reflects a refusal to treat gardens as disposable or incidental, instead affirming their centrality to neighborhood life and to broader movements for food justice, environmental equity, and collective self-determination.

However, this emerging infrastructure exists in an urban policy landscape still characterized by ad hoc protections and limited political accountability. While recent successes in lien parcel acquisitions and sheriff sale monitoring demonstrate growing capacity for coordinated response, the continued threat of property loss and lack of comprehensive city support reveal the limits of technical fixes without deeper structural reform. Protecting community gardens in Philadelphia requires more than improved data; it demands sustained investment in land access mechanisms, earlier intervention strategies, and planning frameworks that treat gardens not as temporary land uses, but as enduring components of equitable urban futures.

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Criteria for selecting assessment tools for local food systems in the context of socio-ecological transitions

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Abstract

Local food systems (LFSs) have attracted growing interest around the world as locally rooted alternatives to globalized food supply chains. LFSs address persistent multidimensional challenges such as food insecurity, malnutrition, and environmental degradation while advancing more equitable and sustainable food systems, a process often referred to as a socio-ecological transition. Evaluation plays a key role in this process by helping LFS stakeholders clarify priorities, identify strengths and vulnerabilities, measure progress, inform necessary adjustments, and underpin accountability. Numer-

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ous LFS assessment tools have been published in scholarly and organizational documents to support holistic evaluation mechanisms covering the social, economic, environmental, and governance dimensions of sustainability. However, researchers and practitioners lack clear guidance on how to choose appropriate assessment tools. This study aimed to identify criteria for selecting LFS evaluation tools that can support effective socio-ecological transitions. Through a scoping review, we identified 22 holistic evaluation tools encompassing 24 components that contribute to a more sustainable vision of LFS. Our analysis yielded seven criteria to guide tool selection. These include (1) relevance to the local context; (2) capacity to assess strengths, assets, and challenges; (3) capacity to guide action; (4) use of a holistic and innovative framework; (5) comparability across territories and scales; (6) community and citizen participation; and (7) capacity to monitor and evaluate deep, systemic transformations. Following our analysis, we recommend adding an evaluation component focused on transition dynamics to monitor structural changes, particularly shifts in norms, policies, and rules that support local food initiatives. This component would also identify the structural barriers and resistance that impede the initiatives' consolidation. We further recommend that the selection of evaluation components be driven by a collective, stakeholder-led process to ensure alignment with local priorities. Future efforts should prioritize improving data accessibility, strengthening the inclusion of perspectives from vulnerable and Indigenous communities, and establishing mechanisms to explicitly link evaluation findings to policy decision-making.

Keywords
local food systems, sustainable food systems, food system governance, socio-ecological transition, assessment tools, sustainability metrics, food security

Introduction and Literature Review

Local food systems (LFSs) have attracted growing interest worldwide as responses to increasing concerns about the social, economic, and environmental consequences of globalized food supply chains, such as persistent food insecurity, malnutrition, and the degradation of soils, water, air, and biodiversity (Bisoffi et al., 2021; Campbell, 2021; Farmery et al., 2021). In this article, an LFS refers to a specific territory, generally a municipality, regional county municipality (MRC), or administrative region, where stakeholders concerned with food and agri-food issues collaborate to analyze challenges and implement coordinated solutions that promote equitable and sustainable food systems for present and future populations (Allen & Prosperi, 2016; Blay-Palmer et al., 2020; El Bilali, 2019). Although definitions vary, most LFSs share the goal of reducing inequalities and mitigating the harmful local effects of the globalized food system (Duarte et al., 2025). In this sense, LFSs act as levers to accelerate socio-ecological transition.

Socio-ecological transition is defined as:

> the passage from the current state of the system to a state that is socially more just, inclusive, and ecologically viable, achieved by transforming our democratic practices, modes of production, consumption, living together, and shared narratives, drawing on social relations conducive to social justice and inclusion. (Guay-Boutet et al., 2021, p. 24)

In light of this perspective, the socio-ecological transition of LFSs entails a profound, systemic transformation of food systems to confront planetary limits and social injustices (Audet et al., 2017; Guay-Boutet et al., 2021). It calls for stakeholders to shift behaviors, perspectives and strategies and to tackle priority issues shaping the future of food (Audet et al., 2017). The socio-ecological transition of LFSs also enacts a vision in which these systems progressively achieve a balanced integration of social, economic, environmental, and governance dimensions. According to Blay-Palmer et al. (2021), this integration has the following implications:

- The social dimension of such transition enhances access to healthy food and improves well-being, health, and equity for all.
- The economic dimension strengthens local agri-food production and the vitality of local businesses. It fosters fair and local

food networks that keep economic activity local and promote equitable sharing of value and risk.
- The environmental dimension focuses on addressing climate change and preventing ecosystem degradation.
- The governance dimension promotes participatory, inclusive, and democratic governance. Such governance shapes the policies, actions, processes, and institutions that define the food supply chain and food environment (Delaney et al., 2018; Moragues-Faus et al., 2017).

Framing LFSs as levers of socio-ecological transition implies that their role goes beyond the local projects they implement. They also have the capacity to influence the rules, norms, policies, and institutional arrangements that shape food systems and to support the consolidation of sustainable and equitable practices (El Bilali, 2019; Audet et al., 2017; Bui et al., 2016; Audet et al., 2024).

However, the socio-ecological transition of LFSs faces significant governance challenges. These challenges include the fact that LFSs operate at a territory scale within centralized governance structures (Boulianne et al., 2021; Lever et al., 2019). Although LFSs often appear politically acceptable, they lack structured institutional support and face regulations that ultimately reinforce globalized food supply chains (Audet et al., 2017; Mundler & Boulianne, 2022). In addition to these structural and institutional constraints, governance challenges also concern how priorities are defined and operationalized within LFS initiatives. The core requirements for ensuring food security and sustainable population health— namely, justice, equity, health protection, and environmental stewardship—remain weakly embedded in the actions of LFSs (Dorr et al., 2021; Rochefort et al., 2021). Moreover, LFSs rarely conduct holistic evaluations of the environmental, economic, and social impacts of their initiatives (Kang et al., 2022; Schiff et al., 2022), even though such assessments are essential for steering transitions (Lopez-Merino & Lamine, 2024; Marshall et al., 2021). In this context, demonstrating whether transformative processes are occurring in practice requires indicators and evaluation tools that capture the complexity of sustainable food systems and integrate multiple viewpoints (Audet et al., 2024; Hansson et al., 2024).

Numerous LFS assessment tools have been developed and published in both scholarly and gray literature (e.g., organizational reports, research reports, methodological guides). Among these, some are explicitly holistic, addressing at least three of the four dimensions of sustainability—environmental, social, economic, and governance (Doernberg et al., 2022; Landert et al., 2017). A few reviews have attempted to systematically catalogue and analyze tools specifically designed to assess LFSs (Alrøe et al., 2016; Garcia et al., 2025; Lopez-Merino & Lamine, 2024; Marchand et al., 2014; Sirdey et al., 2023). These reviews report that most tools focus on only one or two dimensions of sustainability or are limited to a specific sector—most often agricultural production—rather than capturing the multidimensional and systemic nature of LFSs. Moreover, the tools' indicators are rarely tailored to the specificities of local contexts, which limits their relevance and applicability.

Alrøe et al. (2016) emphasized that no single tool can meet all assessment needs. Their review highlights both the potential and the limitations of multicriteria assessments; the authors recommended the combination of complementary tools, the involvement of stakeholders, and methodological transparency to enhance decision-making. Other reviews stress the need to integrate diverse forms of knowledge and value systems. Sirdey et al. (2023) called for more systemic, multiscale, and participatory approaches. Lopez-Merino and Lamine (2024) advocated for a "post-normal" assessment perspective that recognizes the interdependence of ecological and socio-economic systems, the importance of past and future trajectories, and the central role of stakeholder engagement in evaluation processes.

Although relevant criteria for tool selection exist, such as the 11 criteria proposed by Marchand et al. (2014) to evaluate farms, it is noteworthy that only two tools were considered to establish these criteria. These two tools have focused on a single link in the food supply chain. Garcia et al. (2025) set out clear criteria for selecting and refining indicators, but they point out that these criteria are

inconsistently applied in practice. They also highlighted the lack of a clear, shared definition of sustainability in many tools and pointed to the fragmentation of conceptual frameworks and methodologies as a barrier to coherence and comparability. In this study, a conceptual framework for LFS evaluation refers to a structured model that establishes key sustainability components and guides how LFS performance is assessed and interpreted (Food and Agriculture Organization [FAO], 2014; Moragues-Faus & Marceau, 2018). A review of the gray literature on LFS governance (Rabialahy & Guillaumie, 2022) also recommends combining evaluations of processes and outcomes, while considering local resources and time constraints.

Despite the value of these contributions, none of these reviews explicitly address the criteria for selecting tools suited to evaluating the socio-ecological transitions of LFSs. In particular, these reviews overlook the need for tools that capture transformative processes, including structural changes through the implementation of alternative initiatives (e.g., organic farming, food hubs, community-supported agriculture, institutional procurement, cooperatives). Likewise, they do not examine changes within the policies, rules, norms, and infrastructures that maintain the structures of the globalized food system. Understanding these interactions is essential to grasp the pathways of transformation in LFSs (Rabialahy et al., 2025).

Therefore, this study aimed to review the selection criteria that can guide researchers and stakeholders in choosing tools capable of monitoring socio-ecological transitions of LFSs, capturing both progress toward sustainability and the transition dynamics that drive change. This work was part of a broader research project aimed at fostering dialogue between stakeholders and deepening understanding of the socio-ecological transition of Quebec's LFSs (Guillaumie et al., 2021). It also sought to provide an updated overview of available LFS assessment tools to support the development of robust, context-appropriate evaluation practices for LFSs in Québec and, more broadly, across Canada. More specifically, the study pursued three objectives: (1) identify the main characteristics of holistic assessment tools for LFSs, including their objectives, conceptual foundations, criteria for indicator selection, and key components; (2) analyze the strengths, limitations and recommended applications of these tools; and (3) document the recommended criteria for selecting assessment tools from a socio-ecological transition perspective.

Applied Research Methods

The scope of this study focused on LFS evaluation tools applicable in contexts similar to those of Québec and Canada. In this study, evaluation is understood beyond accountability purposes, as a strategic lever to assess and support the transformative capacity of LFS initiatives. Accordingly, our intention was to examine whether and how existing tools enable the assessment of the structural and systemic changes that characterize socio-ecological transitions. The following subsections detail the methodological steps undertaken to identify and analyze LFS assessment tools. They describe the study design, the search strategy, the eligibility criteria, the coding and data analysis procedures, and the theoretical approaches informing our understanding of socio-ecological transition.

Study Design

To identify LFS assessment tools, we carried out a systematic search of scholarly and gray literature (e.g., organizational reports, research reports, methodological guides) in March 2024. The review followed a scoping review approach inspired by Arksey and O'Malley (2005) and refined by Levac et al. (2010). This iterative approach can map the full breadth and depth of relevant evidence across scholarly and gray sources, regardless of study design, and allows the search strategy to be refined as new insights emerge (Arksey & O'Malley, 2005; Levac et al., 2010). This approach is particularly appropriate for complex or heterogeneous topics, helping researchers and decision-makers to synthesize current knowledge, reveal research trends and gaps, and incorporate stakeholder perspectives when validating findings (Granheim et al., 2020; Pham et al., 2014).

Search Strategy

We used an iterative three-part search strategy combining controlled vocabulary (e.g., MeSH, CAB Thesaurus) when available and free text

terms. First, we built three sets of terms: (1) food systems terms (e.g., food system / policy / council / strategy / initiative / project), (2) territorial qualifiers (e.g., community / local / municipal / regional / territorial), and (3) evaluation terms (e.g. evaluation / indicator / performance / measurement / tool). Within each set, terms were searched as synonyms with "or," and the three sets were combined with "and" to yield the query structure: (food system terms OR synonyms) **AND** (territorial terms OR synonyms) **AND** (evaluation terms OR synonyms). Second, we applied this structure in four bibliographic databases: CAB Abstracts, Food Science and Technology Abstracts, Ovid MEDLINE, and Web of Science. We then used the same keyword structure in English and French to search gray literature through Google and Google Scholar. Screening proceeded sequentially by page and stopped once three consecutive pages yielded no documents relevant to LFS evaluation. Each page displayed approximately 10 results. Third, we performed targeted follow-up searches when a paper merely mentioned a tool or provided a brief description. Given that the documentation for the tools retained in this study was often incomplete, we emailed authors, when applicable, to request additional materials, such as data collection grids or questionnaires, in order to enrich the analysis. Any additional documents obtained through this follow-up were added to the review corpus.

Eligibility Criteria

Documents were included when they met the following criteria:

1. They presented a food-system evaluation framework or an assessment tool for LFSs;
2. They addressed at least three of the four sustainability dimensions (social, economic, environmental, and governance);
3. They were designed for a local, municipal, or regional scale;
4. They targeted high-income contexts in Europe, North America, Australia or New Zealand that are similar to those of Québec and, more broadly, Canada; and
5. They detailed operational aspects such as conceptual foundations, development and validation procedures, or practical steps for implementation.

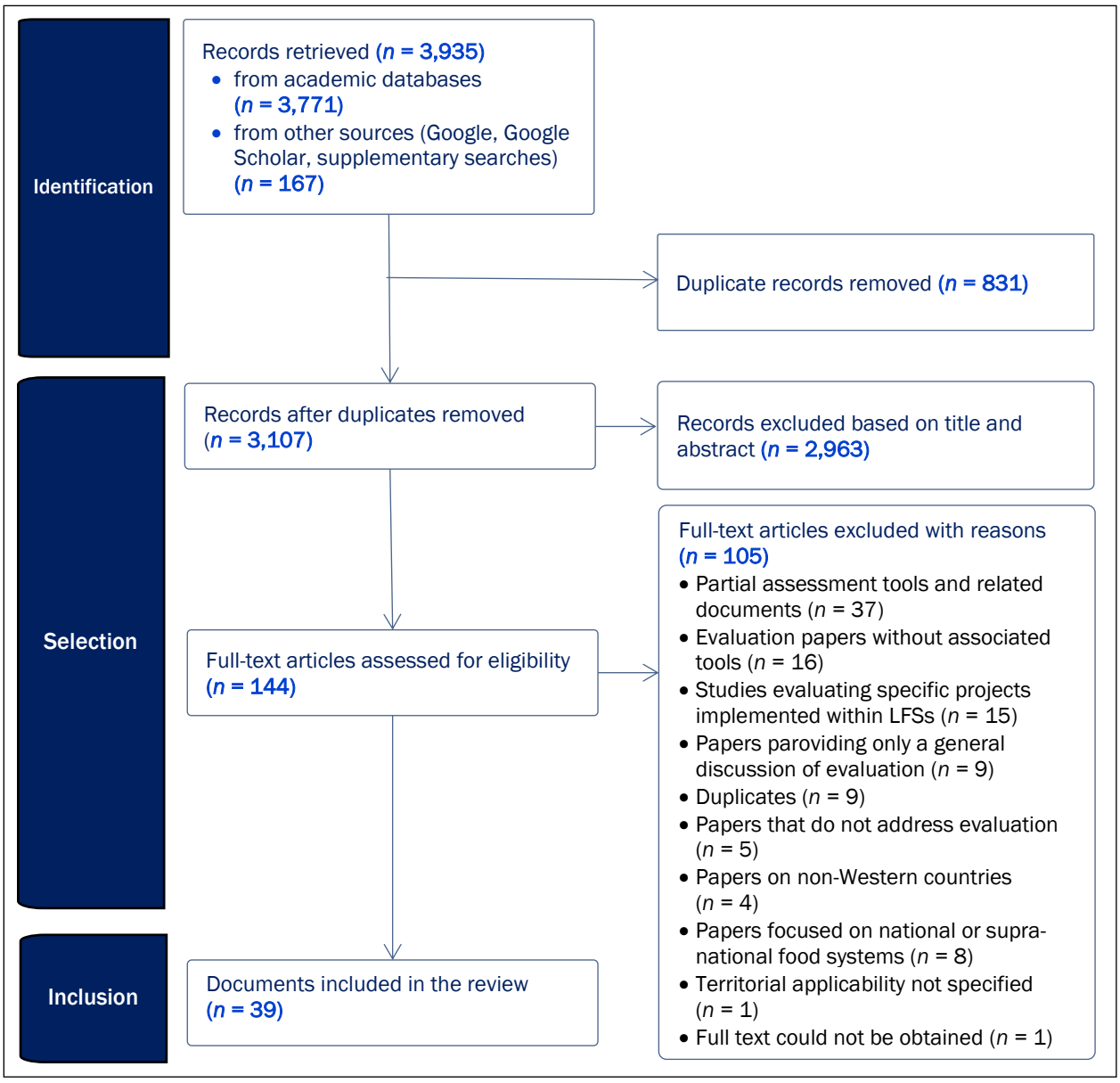
Study design and publication year were unrestricted. Studies were excluded if they were written in a language other than French or English; focused solely on provincial, national, or supranational scales; or mentioned a tool without describing it. Two reviewers screened titles and abstracts independently, then assessed full texts. Inter-rater reliability was high (Cohen's kappa values of 0.96 for the first phase and 0.83 for the second). Disagreements were resolved through discussion until consensus was reached. Figure 1 shows the flow diagram of this process.

Theoretical Approaches to Socio-Ecological Transition

Our intention was to examine whether and how LFS evaluation tools enable researchers and stakeholders to assess structural and systemic changes, as well as the emergence and consolidation of sustainable and equitable initiatives. With this in mind, we employed two complementary theoretical approaches to socio-ecological transition. These approaches helped clarify what constitutes transformative change and informed both our analysis of the components assessed by tools and the recommended criteria for tool selection, particularly those aligned with LFS equity and sustainable population health. The first theoretical approach is reflexive governance (Grin, 2010), derived from the field of sustainability transitions. The second is sustainable health promotion (Hancock, 1993, 2002), grounded in a socio-ecological systems perspective (Bricas et al., 2021).

Reflexive governance builds on the multilevel perspective (Geels & Schot, 2010), which describes how transitions unfold through interactions at three nested levels: niche, regime, and landscape. Niches are protected spaces where radical practices emerge through entrepreneurs, NGOs, and citizens. Regimes are the dominant configurations of policymakers, consumers, civil society organizations, scientists, and interest groups. Regimes also include the dominant rules, norms, and infrastructures that stabilize current systems through lock-in

Figure 1. Process for Including Documents in this Review



mechanisms (i.e., resistance to change that impedes the success of more sustainable niches; Audet et al., 2017; Geels & Schot, 2010). The landscape consists of exogenous forces that can destabilize a regime, such as financial, geopolitical, or ecological events, thus creating "windows of opportunity" for consolidated, sufficiently developed niches (Audet et al., 2017; Geels & Schot, 2010). The theoretical advantage of this transition perspective lies in viewing these niches as potential agents of social transformation, as they develop new practices, norms, and visions that offer alternatives to those promoted within the dominant globalized food system (Audet et al., 2024). Reflexive governance theory analyzes how actors steer change across these levels by using agency, or the capacity of actors to act intentionally and influence transition trajectories (Grin, 2010). The assumed goal of the actors is to align innovations within the niche with fundamental changes in the regime and to exploit landscape disruptions to create transition pathways (Grin, 2010).

Sustainable health promotion (SHP) was originally conceived to highlight the interdependence of the food supply chain, ecological sustainability, and population and planetary health (Kickbusch, 2010). SHP conceptualizes sustainable health as an outcome of social, economic, and environmental relations supported by good governance (Hancock, 1993). Widely applied in North American community food initiatives (Hancock et al., 2017), SHP advocates a deep transformation toward an ecologically and socially sustainable economy. SHP emphasizes the equitable distribution of natural resources and wealth to meet present and future needs. SHP advances four essential attributes, namely ecological sustainability, urban quality of life, community conviviality, and social equity (Hancock, 2002; Hancock & Gibson, 1996). It relies on empowerment, community health, and citizen participation to strengthen local development dynamics and cross-sector collaboration (Russell & de Viggiani, 1997; Thualagant & Jelsøe, 2015).

Coding and Data Analysis

We developed a coding template and piloted it on 10 documents before applying it to all included sources. For each tool, we recorded its name, the country of origin, its purpose, the sustainability dimensions it covers, and the number of indicators it features. We noted the tool's data collection methods, guiding concepts, validation procedures, licensing status, and contact details. The country of origin was identified based on the affiliation of the first author. We summarized quantitative variables using descriptive statistics including the numbers of indicators and sustainability components addressed. We also coded the conceptual frameworks, the criteria for selecting dimensions and indicators, the implementation steps, the data handling procedures, the interpretation guidance, and any supporting software. Verbatim narrative passages on strengths, limitations, and recommendations, including those related to the selection of assessment tools, were copied and examined through thematic analysis to classify, synthesize, and interpret key themes (Miles et al., 2020).

We then performed an inductive analysis of the tools' sustainability components to identify convergences, divergences, and trends in the way they address LFS sustainability. In the first stage, we retained only tools with explicit indicators or questionnaires that could be converted into indicators. We excluded tools that provide only a conceptual framework without their own indicators or those that simply suggest indicators from other tools without explaining how to integrate them, since they lacked stand-alone metrics. Following the inductive identification of sustainability components across the reviewed tools, we constructed a taxonomy based on the full set of tools included in the study. As an initial reference, we drew on the FAO's (2014) Sustainability Assessment of Food and Agriculture Systems (SAFA) framework, which offers a comprehensive, robust, and empirically tested taxonomy of 21 sustainability components (themes) and 58 subthemes organized into four dimensions: good governance, environmental integrity, economic resilience, and social well-being. These components represent major sustainability issues at every scale, while the subthemes capture the specific concerns within each component, thereby facilitating comparisons with other sustainability frameworks and tools (FAO, 2014). Developed through extensive consultation, SAFA has proven adaptable to agri-food systems, both terrestrial and aquatic, across multiple scales and for diverse stakeholder objectives, and it has already been applied to LFSs (Zarbà et al., 2025).

The SAFA taxonomy was subsequently expanded to incorporate additional components and subthemes emerging through inductive analysis when they were not covered by SAFA. Three new components were added:

- institutional governance,
- enterprise vibrancy and prosperity, and
- social capital.

Two components were expanded:

- The atmosphere component now encompasses climate change mitigation (actions to reduce greenhouse gas emissions) and adaptation (actions to adjust to impacts of climate change).
- The vulnerability component now covers resilience and food autonomy.

Two components were merged:

- The land and water components were merged, as proposed by Peano et al. (2015), to reflect their strong interdependent indicators.
- Three subthemes were added to governance: citizen participation, the participation of vulnerable populations, and public policy implementation.

These adjustments yielded a taxonomy of 24 components and 68 subcomponents, reflecting the components identified across all reviewed tools. The taxonomy is presented in Appendix A.

In the second stage, we coded indicators from each retained tool. We assigned each indicator to a single component within this adapted SAFA taxonomy, ensuring mutual exclusivity without redundancy (Gebara et al., 2024). However, we classified some indicators into multiple components when their description clearly indicated their application to more than one component.

In the third stage, we identified which sustainability components were most relevant for monitoring and evaluating LFS transition dynamics. Using the theoretical approaches to socio-ecological transition presented earlier, we analyzed how each component and its associated indicators reflect structural and institutional changes—such as changes in policies, rules, norms, infrastructures, and collective dynamics—that support or impede the consolidation of LFS initiatives. A component was considered particularly relevant when the scope and meaning of its indicators explicitly addressed these aspects of systemic change.

Results

The results first describe the characteristics of the identified LFS assessment tools, including the sustainability components they assess and their capacity to monitor transition dynamics. They then present the main challenges, levers, and recommendations identified in the reviewed documents, before proposing criteria to guide the selection of an LFS assessment tool.

Characteristics of the Tools Identified

We identified 39 records including 22 holistic LFS assessment tools that address at least three of the four sustainability dimensions. Table B in Appendix B summarizes the 22 tools, and the full list of sources and the additional documents reviewed are presented in Tables C1 and C2 in Appendix C. Thirteen of these holistic tools appeared in peer-reviewed journals and nine in gray literature. Seventeen of the tools had been published since 2014. Based on the affiliation reported for the first author, nine of these were developed in European countries (Italy, France, the United Kingdom, Germany, and Switzerland) and eight in North America (six of them in the United States and two in Canada). Seventeen tools covered the entire food supply chain, including production, processing, distribution, retail, consumption, and waste management, at the community or municipal scale. Eighteen addressed all four sustainability dimensions.

In terms of aims, 11 of the tools sought to provide an overall assessment of a given LFS's sustainability performance and compare it with other LFSs. Twelve were intended to inform decision-making regarding projects or policy priorities. Four tools aimed to evaluate the effectiveness of projects that had been implemented, and three focused on policy effectiveness. Two tools had very specific aims: one measured citizen and stakeholder participation within an LFS (FAO et al., 2021; O'Brien & Cobb, 2012), and the other assessed Indigenous food systems (First Nations Development Institute, 2014).

Twenty tools used at least one conceptual framework. The most common disciplinary orientations for these conceptual frameworks include political science (e.g., Advocacy Coalition Framework), environmental studies (e.g., life cycle assessment), and sustainability studies, notably the SAFA framework (FAO, 2014) and the Milan Urban Food Policy Pact (MUFPP) monitoring framework (FAO et al., 2021). Several tools adapted pre-existing tools or combined them with new instruments.

Our analysis shows three main criteria for selecting indicators. First, tools favor indicators for which data are easy to collect, either because they already exist in administrative or research databases

or because they can be obtained without using excessive resources (e.g., Cirone et al., 2023; Lulovicova & Bouissou, 2024; Mundler & Laughrea, 2016). Second, the tools generally rely on quality standards such as relevance, parsimony, scientific grounding, robustness, accuracy, measurability, clarity of presentation, usefulness for tracking progress and causal links, and transparency regarding what is covered. Several tools explicitly refer to the SMART standard (specific, measurable, accessible, reliable, timed; e.g., Bouroullec & Victoria, 2014; Darrot et al., 2022; Moragues-Faus & Marceau, 2018). Third, indicator choice seeks to reflect the priorities of local stakeholders (e.g., Cirone et al., 2023). This process is often political, participatory, and inclusive, shaped by the composition of stakeholders and their divergent interests and power dynamics (e.g., Valette et al., 2024).

The reviewed tools use markedly different indicator weighting approaches. Some tools adopt equal weighting, applying a noncompensatory principle that gives each indicator the same importance to preserve a balanced representation of each dimension's components (e.g., Cirone et al., 2023; Darrot et al., 2022; Peano et al., 2014; Peano et al., 2015). Others, by contrast, apply unequal weights but emphasize the difficulty of reaching consensus on each indicator's level of importance (e.g., Bouroullec & Victoria, 2014). Validation procedures were also rarely described. When reported, validation generally relied on face validity, whereby experts checked whether each indicator seemed relevant and appropriate for what the tool is intended to measure. Some authors have developed manuals to help people use these tools (e.g., Carey & Cook, 2021; FAO, 2023; Miewald, 2009; National Research Center Inc., 2006a). The tools developed for Indigenous food system assessment indicate community control, encouraging Indigenous communities to set their own objectives, choose data collection methods, and develop context-appropriate strategies (e.g., First Nations Development Institute, 2014; 2017).

Sustainability components assessed in the LFS evaluation tools

Of the 22 holistic tools included in the study, 20 provided explicit indicators or questionnaires convertible into measurable indicators and were therefore eligible for an analysis of their components. Across these 20 tools, a total of 2,358 indicators were extracted and subsequently classified using the adapted taxonomy, which grouped sustainability issues into 24 components numbered from C1 to C24 (see Appendix A). Each component comprises subthemes that capture specific issues.

Figure 2 provides an overview of how indicators are distributed across sustainability components, highlighting which issues are prioritized, or overlooked, across reviewed tools. The following results summarize the main patterns observed within each sustainability dimension.

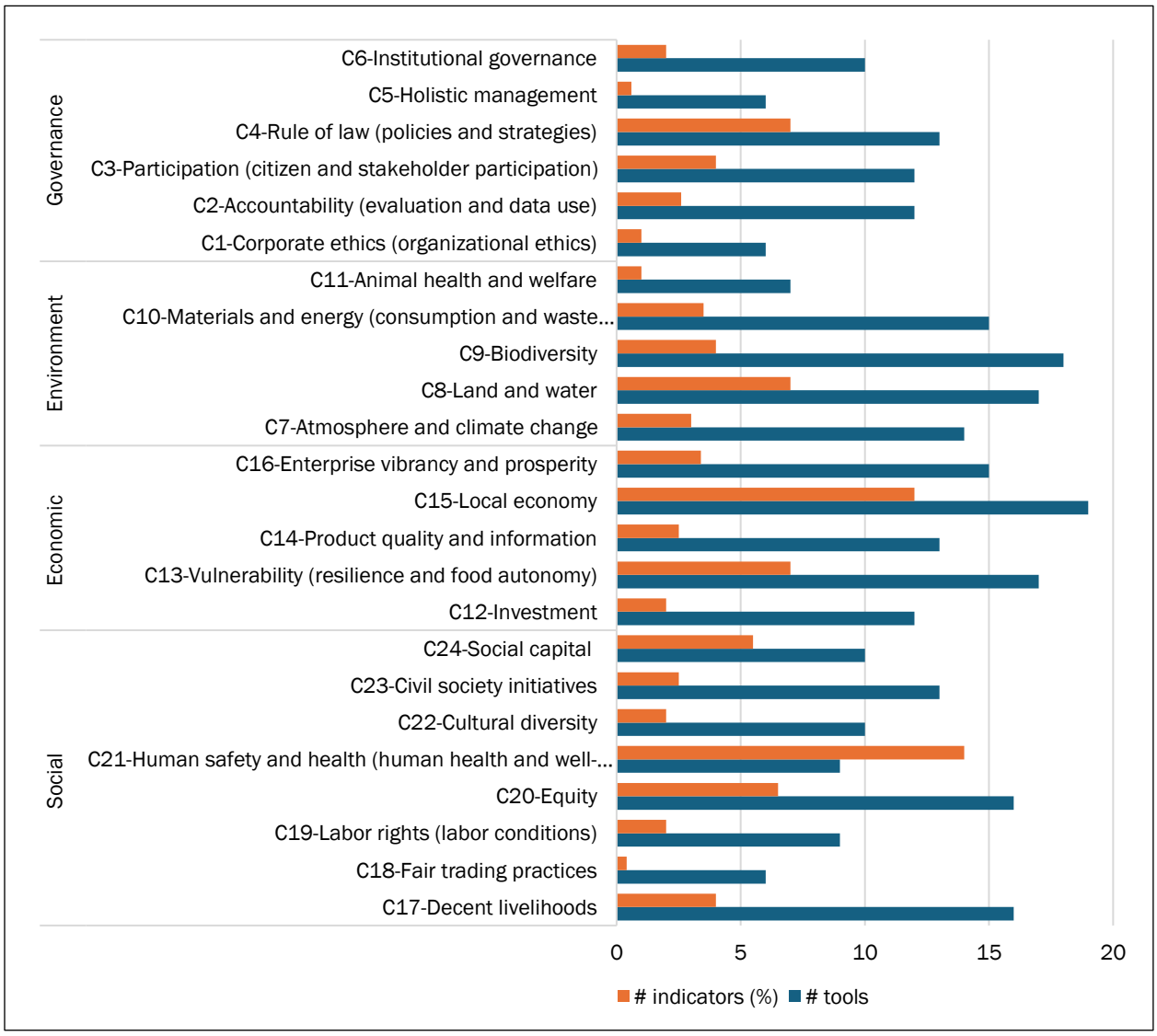
In the governance dimension, the most widely assessed component was *C4—Rule of law (policies and strategies)*, appearing in 13 tools. *C3—Participation (citizen and stakeholder participation)* followed, yet only one tool explicitly assessed the participation of vulnerable groups (Moragues-Faus & Marceau, 2018), and another focused on producer participation (Peano et al., 2015). *C2—Accountability (evaluation and data use)*, *C6—Institutional governance* and *C1—Corporate Ethics* (organizational ethics) received minimal attention.

The environmental dimension was led by the *C8—Land and water* component (17 tools), followed by *C9—Biodiversity*, *C7—Atmosphere and climate change*, and *C10—Materials and energy (consumption and waste management)*. The *C11—Animal health and welfare* component was very rarely considered, making up less than 1% of indicators.

In the economic dimension, *C5—Local economy* was the dominant component (addressed by 19 tools). *C13—Vulnerability (resilience and food autonomy)* was the next most common, whereas the *C12—Investment* and *C16—Enterprise vibrancy and prosperity* components were covered in fewer tools and indicators.

In the social dimension, *C21—Human safety and health (health and well-being)* was the most frequently assessed component but appeared in only nine tools and focused mainly on access to healthy food. *C20—Equity* and *C17—Decent livelihoods* followed, while *C23—Civil society initiatives*, *C24—Social capital*, and *C22—Cultural diversity* were limited. Food sovereignty and respect for Indigenous cultures appeared in only three tools, with one indicator each.

Figure 2. Sustainability Components of Local Food Systems Assessed (*n* = 20)



Components for monitoring and evaluating LFS transition dynamics

As outlined in the third stage of our analysis, we assessed which sustainability components were most relevant for monitoring and evaluating LFS transition dynamics. A component was considered particularly relevant when its indicators explicitly reflected structural and institutional changes (e.g., shifts in policies, norms, infrastructures, and collective dynamics). Based on this analysis, we showed that, while the components identified in these tools contribute to a broader vision of sustainability, none were explicitly designed to monitor and evaluate the systemic transformations that characterize socio-ecological transitions in food systems. Nevertheless, six components emerged as particularly relevant for capturing these dynamics. These components include, within the governance dimension, *C4—Rule of law (policies and strategies)*, *C3—participation (citizen and stakeholder engagement)*, and *C5—holistic management*; *C12—Investment* and *C16—Enterprise vibrancy and prosperity* within the economic dimension; and within the social dimension, *C20—equity* and *C24—social capital.*

C4—Rule of law (policies and strategies) captures the rules, norms, and structures that facilitate

or limit the diffusion of local food initiatives and signal the need for policy or structural change (e.g., FAO, 2014; Moragues-Faus & Marceau, 2018). Component *C3—participation (citizen and stakeholder participation)* records how decision-making power is shared, with explicit attention to materially affected groups (e.g., FAO, 2014; FAO et al., 2021; Moragues-Faus & Marceau, 2018). *C5-Holistic management*, particularly through the sustainability management plan subtheme, signals the existence of integrated, iterative planning across all four dimensions (e.g., FAO, 2014). Within the economic dimension, *C16—Enterprise vibrancy and prosperity* assesses how LFSs or local governments support sustainable local enterprises in achieving prosperity and economic viability (e.g., Center for Whole Communities, 2009; Peano et al., 2015). *C12—Investment* assesses the financial, human, and infrastructural resources devoted to transformation, such as agroecological research, facility upgrades, and community-led initiatives (e.g., Carey et al., 2018; FAO, 2014). Finally, within the social dimension, *C20—Equity* appears relevant as it assesses the fairness and inclusiveness with which resources are distributed, opportunities are offered, and decisions are made, ensuring justice for all. This component also incorporates equitable access to productive resources, such as land, financing and healthy food, as well as non-discrimination and pay equity (e.g., FAO, 2014). The *C24—Social capital* component allows for measuring the strength of LFS actor networks and their capacity to leverage formal and informal institutional resources in support of more equitable and sustainable LFS transformations (e.g., Peano et al., 2015).

Challenges, Levers, and Recommendations for Using Holistic LFS Assessment Tools

Our analysis revealed six key challenges that limit the use of holistic LFS assessment tools, along with levers and recommendations mentioned in the reviewed documents.

Limited access to administrative data

Several tools relied on administrative data from public agencies, community organizations, and enterprises, but these datasets were frequently incomplete, difficult to compare across territories, and infrequently updated (e.g., Cirone et al., 2023; Moragues-Faus & Marceau, 2018). To fill this gap, territories often gather primary data through surveys or semi-structured interviews (e.g., Doernberg et al., 2022). Thus, improving access to public administrative databases and supporting their regular updating should enable the ongoing monitoring of indicators (e.g., Moragues-Faus & Marceau, 2018).

The lack of standardized evaluation approaches

The reviewed tools used nonstandardized approaches, which limited comparison across territories and sometimes undermined local specificities. This challenge is exacerbated by the limited involvement of small businesses in the evaluation process and the difficulty of adapting tools to different scales (e.g., Landert et al., 2017; Moragues-Faus & Marceau, 2018). To address this, some tools recommend developing a standardized core set of holistic components that can capture the interactions and interdependence between LFs while accommodating local contexts (e.g., FAO, 2014; Moragues-Faus & Marceau, 2018).

High evaluation costs

Reviewed documents highlighted that comprehensive assessments require significant resources for consultant fees, data management, and logistics. Consequently, limited resources may constrain the scope of evaluations (e.g., Christensen & O'Sullivan, 2015; Peano et al., 2014). Some researchers have recommend defining the evaluation's scope early in the process, choosing between a rapid assessment or an in-depth assessment, depending on the available resources and the information required for the project (e.g., FAO, 2023). A rapid scan assessment provides an overview of an LFS based on available data, stakeholder knowledge, and institutional documents to determine what issues require deeper investigation. A subsequent in-depth assessment gathers and analyzes quantitative and qualitative data on the systemic issues, bottlenecks, and structural vulnerabilities identified by the rapid assessment (e.g., FAO, 2023).

Insufficient inclusion of vulnerable populations

Our analysis revealed that vulnerable populations were rarely included in the evaluation process. Sev-

eral authors also noted that such exclusion can limit the representativeness of data on these groups and the integration of their priorities (e.g., Clark, 2018; Moragues-Faus & Marceau, 2018). To better incorporate the perspectives and the lived realities of vulnerable populations, some tools recommended strategies such as randomizing the postal distribution of surveys, using social variables (e.g., gender, age, income, ethnicity, and location of food banks and grocery stores in low-income neighborhoods) and explicitly evaluating citizen participation (e.g., Clark, 2018; Cohen et al., 2002; Ross & Simces, 2008).

Lack of consideration for processes analysis

Our analysis confirmed that most tools focus on outcomes at the expense of process analysis. Several tools assess performance simply by noting whether specific actions, such as policy adoption, have taken place without examining the underlying dynamics that drive or enable change (e.g., Clark, 2018; Peano et al., 2015). Some authors recommend including process indicators that measure enabling conditions for transition and gather stakeholder feedback on transition mechanisms (e.g., Valette et al., 2024).

Limited dissemination of results

Our analysis revealed that findings were rarely integrated into decision-making processes. Suggested strategies to address this limit included holding regular meetings with policymakers and LFS stakeholders, combined with concise visual presentations of results (e.g., radar charts), which would enhance uptake and stimulate stakeholder dialogue (e.g., Clark et al., 2017; Darrot et al., 2022; National Research Center Inc., 2006b).

Criteria to Guide the Selection of an LFS Assessment Tool

Among the 39 documents included in this study, Doernberg et al. (2022) highlighted that selecting an appropriate assessment tool is challenging due to the wide variety of tools available. The tools demonstrate substantial variability in purpose, scope, scale, level of assessment, stakeholder involvement, and complexity. Doernberg et al. also emphasized the necessity of clarifying stakeholders' needs, resource constraints, and tool strengths and limitations. However, our analysis revealed that these aspects of tool variability are rarely detailed across the reviewed documents, whereas discussions on indicator selection were far more common. Drawing on the challenges, levers, and recommendations identified across the documents, our analysis led to the identification of seven criteria to guide the selection of LFS assessment tools.

Criterion 1. Relevance to the context

Our analysis identified that a relevant tool should allow the flexible selection, addition, or modification of indicators to reflect local contexts and priorities. Tools offering a wide range of indicators enable users to tailor assessments, reveal specific gaps, and encourage stakeholder dialogue (e.g., Landert et al., 2017; Moragues-Faus & Marceau, 2018). These indicators should reflect end-user priorities and support a shared understanding to inform collective action (e.g., Fraser et al., 2005; Moragues-Faus & Marceau, 2018). The tool should also be adaptable across multiple scales and administrative boundaries. A modular approach combining different tools and indicators was recommended to meet assessment needs and adapt to specific contexts (e.g., Doernberg et al., 2022).

Criterion 2. Effectiveness of strengths, assets, and challenges assessment

Several documents highlighted that tools should enable LFSs to identify their strengths (project, policy outputs), assets (available resources, skills, knowledge), and challenges (e.g., Martin & Morales, 2015; Mirzabeiki & Aitken, 2023). Others indicated that tools should help pinpoint the sources of external and internal problems to better highlight potential compromises and guide stakeholder dialogue (e.g., Doernberg et al., 2022).

Criterion 3. Capacity to guide action

Several documents stressed that tools should provide decision-makers with practical recommendations based on assessment findings (e.g., Darrot et al., 2022; Moragues-Faus & Marceau, 2018). These recommendations were described as helping to develop action plans, food policies, and concrete interventions (e.g., O'Brien & Cobb, 2012;

Sparrow, 2016). Others encouraged self-assessment tools, as they provide a rapid, participatory evaluation at a lower cost (e.g., FAO et al., 2021; First Nations Development Institute, 2014).

Criterion 4. Use of a holistic and innovative framework

Our analysis highlighted that tools using a holistic framework are essential for avoiding siloed approaches and capturing interactions within LFSs, particularly the links among sociocultural, agro-environmental, and economic factors (e.g., Doernberg et al., 2022; Peano et al., 2015). Such a framework was reported as helping to reveal mutual influences and highlight needed compromises (e.g., Cirone et al., 2023). Some documents noted that including the governance dimension makes it possible to examine the institutional and political mechanisms shaping the ways that LFSs are structured and to contribute to their sustainability (e.g., FAO et al., 2021; Valette et al., 2024). Others indicated that the framework must also measure emerging concerns, such as entrepreneurs' confidence in managing their activities and their relationships with the local community (e.g., Landert et al., 2017; Peano et al., 2015).

Criterion 5. Comparability between LFSs and across scales

Several documents mentioned that tools must make it possible to compare LFSs across administrative scales and align with national and global benchmarks (e.g., Bouroullec & Victoria, 2014; Lulovicova & Bouissou, 2024). This comparability requires the use of common indicators that can be matched to reference frameworks, such as the Sustainable Development Goals (SDGs; FAO, 2014; e.g., Cirone et al., 2023). Some documents highlighted that a holistic evaluation framework improves the consistency and usefulness of comparative data (Cirone et al., 2023).

Criterion 6. Community participation

Documents indicated that tools should feature mechanisms encouraging broad community engagement, including engagement with vulnerable groups, by raising awareness of LFSs' challenges and starting dialogue on gaps and priorities (e.g., O'Brien & Cobb, 2012; Whitt & Pitt County Food Council Task Force, 2016). Broader stakeholder involvement was reported as creating synergies and driving real change within LFSs (e.g., Chollett & Naidu, 2009).

Criterion 7. Ability to assess deep and systemic transformations of LFSs

Finally, some reviewed documents noted that tools should enable LFSs to construct their own transition trajectories by translating their values and convictions into structural change strategies, and by including indicators that monitor the key structural transformations underpinning socio-ecological transitions (e.g., Moragues-Faus & Marceau, 2018; O'Brien & Cobb, 2012). Priority should be given to indicators that track policies and strategies related to removing regulations that maintain the current unsustainable food system, and those that consolidate alternative initiatives (e.g., Center for Whole Communities, 2009; FAO, 2014; Lambie, 2019; Moragues-Faus & Marceau, 2018; Peano et al., 2015). These indicators should focus on the democratization of governance mechanisms through broader and more inclusive decision-making, and on sustained financial and organizational support to strengthen LFS networks. In addition, indicators should quantify projects that consolidate and strengthen the structures of LFS initiatives and should expose persistent barriers created by the dominant food system (such as policies, norms, or rules that constrain LFS actors) to explicitly identify obstacles to structural change (e.g., Cohen et al., 2002; Darrot et al., 2022; First Nations Development Institute, 2014).

Table 1 synthesizes the seven criteria that emerged from our analysis and presents their practical implications for selecting LFS assessment tools.

Discussion

This study identified 22 holistic LFS assessment tools and revealed recurring challenges and facilitators affecting their implementation. Seven criteria for selecting tools that can support socio-ecological transitions in LFSs were identified. According to our results, an appropriate tool should:

1. Be relevant to the local context by taking a modular approach that combines different suites of indicators and tools;
2. Identify strengths, assets, and challenges to clarify the LFS's achievements and to list available resources, the sources of problems, and the areas where the LFS has room to maneuver in solving them;
3. Guide action by translating findings into practical recommendations for decision-makers;
4. Use a holistic and innovative framework covering social, economic, environmental, and governance dimensions to capture complex interactions and emerging sustainability concerns;
5. Enable comparison across territories and scales through shared indicators that foster cross-territory learning;
6. Include mechanisms to enhance community and citizen participation, especially by improving vulnerable populations' influence on decision-making; and
7. Track deep and systemic transformations by measuring structural changes, such as intersectoral policy changes, inclusive governance reforms, and regime lock-in.

Table 1. Guidance for Selecting Assessment Tools for Local Food Systems (LFSs) Using the Seven Criteria

Criteria	Purpose	Key questions	Implication for tool selection
1 – Relevance to the local context	Ensure that assessment reflects shared issues and priorities	What are the most pressing issues and priorities in our local context, and how do selected components and indicators reflect shared issues and priorities?	Choose tools that allow flexible adaptation of components and indicators, and, when needed, allow combination with other tools to address local priorities and specific contexts
2 – Assess strengths, assets and challenges	Identify achievements, available resources, and process conditions that shape the current performance of LFS	How does the tool assess strengths, assets and challenges? Does it specify processes and sources of problems?	Select tools that assess both results and their underlying processes, identify available resources, and specify sources of problems
3 – Capacity to guide action	Ensure that assessment findings inform planning and decision-making	How does the tool present findings in a way that supports decisions, policies, and actions?	Choose tools that translate findings into practical recommendations for concrete interventions, priorities, and the development of food policies
4 – Use of a holistic and innovative framework	Ensure that assessment addresses the four sustainability dimensions and their interactions (holistic), as well as emerging issues (innovative)	How does the tool integrate social, economic, environmental, and governance dimensions? How does it incorporate emerging issues?	Favor tools that avoid siloed assessment, capture interdependencies across dimensions, make compromises explicit, and address emerging issues
5 – Comparability between LFSs and across scales	Enable meaningful comparison and alignment across territories and governance levels	How does the tool enable comparison across territories and administrative scales? Are its indicators aligned with shared reference frameworks such as the SDGs? *	Favor tools that use shared indicators (same definitions and measurement) to allow comparison across territories and administrative scales, and alignment with national or global reference frameworks like SDGs*
6 – Community participation	Ensure meaningful community participation in the assessment process, including by vulnerable groups	How does the tool engage stakeholders in the assessment process? How are vulnerable and marginalized groups included?	Select tools that include explicit mechanisms for stakeholder engagement and inclusive participation
7 – Ability to assess deep and systemic transformations of LFSs	Ensure that assessment tracks structural and systemic change in LFSs	How does the tool track structural transformations, including changes in policy, market conditions, social norms, and governance democratization that support or impede the consolidation of LFS initiatives?	Choose tools that include components and indicators to track structural changes, including both enabling factors and persistent barriers affecting the consolidation of LFS initiatives

The following subsections discuss the four main findings of this review and their implications for practice.

Tools Often Lack a Clearly Articulated Sustainability Perspective

The first finding is that most tools identified in this study lack a clear and coherent vision of sustainability, even though such a vision is recognized as fundamental to guiding transformation toward sustainability (Kantabutra, 2020). Economic and social dimensions tend to be overemphasized, often driven by production-oriented agendas and a growing interest in the social impacts of LFSs (Massuça et al., 2023). At the same time, environmental and governance components remain underdeveloped (Allen et al., 2019; Cirone et al., 2023; Dezio & Marino, 2018). Notably, although the dominant approach remains primarily focused on economic profitability, key components such as *Investment* and *Enterprise vibrancy and prosperity* are often unmeasured. Moreover, environmental indicators relating to biodiversity, climate change adaptation, and waste management are unequally represented and often superficial, partly due to the lack of disaggregated regional environmental data, particularly for small enterprises (Moragues-Faus & Marceau, 2018). As an example, in the province of Québec, Canada, regional bio-food portraits focus mainly on economic indicators (MAPAQ, 2024). Environmental data are limited to greenhouse gas emissions and water and air quality indicators from regulated establishments subject to reporting (MELCCFP, 2024). Biodiversity data also remain insufficient to rigorously assess biodiversity loss (Biodiversité Québec, n.d.). Such limited attention weakens the potential for a truly systemic and holistic perspective that would balance governance with economic contributions, the protection of ecosystems, cultural diversity, and social equity, including equitable access to livelihoods (Desiderio et al., 2022; Stephens, 2021).

In some cases, the vagueness surrounding the vision of sustainability appears strategic. It allows actors to manage tensions associated with the multiple and sometimes controversial meanings of the notion of sustainability by adapting it to local realities (Theys, 2020). This also facilitates dialogue with local policymakers, which is often shaped by economic orientation and industrial interests, and sidesteps institutional reluctance to deal with the uncertainty that characterizes transitions (Rahe et al., 2018; Stephens, 2021). However, this vagueness can compromise ecosystem preservation (Shi et al., 2019). These findings underscore the need for tools that allow a participatory, systemic approach with a genuinely holistic evaluation framework that equally balances social, economic, environmental, and governance dimensions and incorporates concrete indicators to quantify impacts, monitor progress, and inform decision-making (Blay-Palmer et al., 2020; Garnett, 2014; Zarbà et al., 2025). Implementing such tools requires dedicated resources for planning, data collection, and collaborative analysis with stakeholders (Rabialahy & Guillaumie, 2022).

Tools Have Limited Inclusion of Vulnerable Groups, Indigenous Communities, and Entrepreneurs, and Limited Consideration of Social Inequalities

A second finding concerns the limited integration of vulnerable groups, Indigenous communities, and small entrepreneurs into LFS assessment tools, as well as the limited consideration of social inequalities. Although several authors stress the importance of incorporating vulnerable groups into evaluations, current LFS assessment tools give little attention to them (Moragues-Faus, 2020). Only two tools include indicators on food policies aimed at these populations, and even those indicators measure whether a policy exists rather than measuring such a policy's real impact (Carey et al., 2018; FAO et al., 2021). This omission tends to reinforce the agendas of actors in positions of power, thereby undermining the transformative potential of evaluation and perpetuating existing inequities (Moragues-Faus, 2020). As a result, food justice, where everyone can both access healthy food and shape food governance, remains difficult to achieve in LFSs (Gallardo Gomez & Darrot, 2023; Hochedez et al., 2022).

Indigenous food systems issues were also rarely addressed and often received superficial consideration when they were. One tool, available in two versions, focused on Indigenous food sovereignty (Bell-Sheeter, 2004; First Nations Develop-

ment Institute, 2014). Four others (FAO, 2014; Landert et al., 2017; Moragues-Faus & Marceau, 2018; National Research Center Inc., 2006b) simply noted whether traditional knowledge was considered, without assessing how it was integrated or its effects. This superficial approach leaves critical blind spots, particularly regarding the use and transmission of traditional knowledge and Indigenous self-determination (Abdul et al., 2024). Effective evaluation must co-design indicators with Indigenous communities. This requires decolonial approaches that recognize Indigenous authority and the revitalization of traditional Indigenous knowledge and food practices, and that give priority to lived experience and to reciprocal relationships with land, water, and non-human life (Daigle, 2023).

Small entrepreneurs also receive little attention in existing evaluation tools. Current economic evaluation approaches often fail to capture their contributions (Phillips Goldenberg & Colasanti, 2017). In addition, small entrepreneurs are rarely inclined to participate in evaluation processes (Enthoven & Broeck, 2021; Phillips Goldenberg & Colasanti, 2017). Consequently, samples tend to be small, and their economic impact is likely to be systematically underestimated (Enthoven & Broeck, 2021; Phillips Goldenberg & Colasanti, 2017). In this context, a life-cycle costing approach can help LFS stakeholders clarify how private, public, and external costs are distributed among the various actors along a food supply chain (Pelletier, 2015). LFS governance should therefore recognize small enterprises as transition drivers by giving them formal seats at decision-making tables and actively involving them in evaluation activities (Rabialahy et al., 2025).

Our findings also suggest that the structural causes of social inequalities that shape food concerns for marginalized groups remain largely unaddressed in LFS assessment. Only three tools (Carey et al., 2018; Center for Whole Communities, 2009; Moragues-Faus & Marceau, 2018) address the structural determinants of social inequality, such as poverty, discrimination, precarious labor conditions, and inadequate housing, which shape access to healthy food and overall well-being (Cohen, 2020). The predominance of individual factors, such as diet quality, prevalence of diseases that may be diet-related (e.g., diabetes, cardiovascular illness), obesity rates, and adherence to public nutrition programs or dietary guidelines, reveals an underlying assumption that food-related challenges stem primarily from individual behaviors rather than from structural inequities (Cohen, 2020). This individual lens is too narrow to drive a meaningful socio-ecological transition, which implies structural changes (Bricas et al., 2021; Geels, 2024). Such sparse integration of structural determinants means that LFS assessment tools generally fail to adopt a broad vision of health that includes the reduction of social inequalities (Cohen, 2020). These findings highlight the need for assessment tools that adopt a broader vision of equity by integrating indicators related to the living conditions that underpin equity and by establishing data-sharing practices across sectors to systematically monitor how LFS initiatives contribute to reducing inequities (Cohen, 2020; Pozelli Sabio & Lehoux, 2019).

Limited Strategic Value Due to an Unresolved Methodological Tension and Gaps in Governance Analysis

The third finding highlights that existing assessment tools face both a methodological tension and important gaps in governance analysis, which together limit their ability to support strategic decision-making. The methodological tension arises from two evaluation approaches in LFS assessment: in-depth assessments offer comprehensive insights but rely on laborious methods, whereas rapid scans are simple but superficial. In-depth assessments are valued for their comprehensive coverage. They use extensive indicator sets and expert-led analysis cycles to capture the complexity of LFSs. However, they require consultants' services, which incur high costs and thus limit their feasibility in resource-limited contexts (Murrell et al., 2022; Schiff et al., 2022). They are also often criticized for failing to produce summaries that can inform strategic decision-making (Sirdey et al., 2023). Conversely, rapid scan tools prioritize affordability and ease of use by drawing on available quantitative data or stakeholder perceptions. They offer a viable alternative where financial and technical capacities are limited (Murrell & Jones, 2020; Schiff et al., 2022) but risk delivering superfi-

cial or incomplete analyses of critical LFS issues (Marchand et al., 2014). Self-assessment frameworks, such as the MUFPP monitoring tool, are lauded for their rapid and participatory evaluation, yet often struggle to adapt to local specificities, which limits their effectiveness (Sibbing et al., 2022). Ultimately, the choice between in-depth assessments and rapid scans depends on contextual factors such as available resources, objectives, and stakeholder capacities, as well as how the evaluation will be used, whether for strategic decision-making or for performance comparison. However, it is important to remain aware that each approach involves trade-offs and reflects strategic choices about what to prioritize in evaluating LFSs.

Furthermore, most evaluation tools, whether in-depth or rapid, fail to monitor whether and how their findings influence policy decisions (Ubertino et al., 2024). They also rarely analyze the power relations and competing interests among stakeholders that shape these processes (Prosperi et al., 2015). Similarly, few indicators assess the interactions between LFS initiatives and the dominant conventional food systems, even though these are key to identifying structural barriers to transformation (Grin, 2020). Another critical gap concerns the linkages across governance levels (local, regional, and national), which tools rarely address despite its importance for aligning political efforts and ensuring the coherent transformation of food systems (Robert & Mullinix, 2018). In this context, the ability of indicators to inform and influence policy decisions becomes particularly important along with the effective dissemination of assessment results. Evaluations should clarify their relationship to policymaking, examine how findings are communicated and used (Blay-Palmer et al., 2020), and actively involve policymakers through mechanisms such as public reporting and pre-deliberative consultations (Ubertino et al., 2024). Such improvements would enhance the potential of assessment tools to act as true levers for informed and systemic change.

Four Assessment Tools Emerge as the Most Aligned with Socio-Ecological Transition

The fourth finding concerns four holistic tools that emerge as better aligned with the selection criteria identified in this study, while also remaining adaptable to local contexts:

1. Indicators Toolbox for Measuring Progress in Sustainable Food Cities (Moragues-Faus & Marceau, 2018)
2. City Region Food System (CRFS) toolkit (Carey et al., 2018)
3. Food Policy Audit (O'Brien & Cobb, 2012)
4. Community Food Project Evaluation Toolkit (National Research Center Inc., 2006b)

First, all four tools allow flexible adaptation of components and indicators and can be combined to reflect local priorities and specific contexts (Criterion 1). Two of these tools assess 23 sustainability components, providing a comprehensive basis for identifying priority issues, and their wide range of indicators supports the development of dashboards to monitor progress (Carey et al., 2018; Moragues-Faus & Marceau, 2018). The Food Policy Audit also begins by identifying key local issues such as public health, economic development, environmental impacts, social equity, and land conservation (O'Brien & Cobb, 2012). Second, they assess both results and underlying processes, helping identify strengths, available resources, and sources of challenges (Criterion 2). Third, they translate findings into practical orientations that support concrete interventions and food policy development (Criterion 3). Fourth, they avoid siloed assessment by adopting a holistic approach; integrating social, economic, environmental, and governance dimensions; capturing interdependencies and emerging issues such as the capacity of actors to act and Indigenous sovereignty (Criterion 4). Fifth, their use of shared indicators enables comparison across territories, while the CRFS Toolkit (Carey et al., 2018) aligns explicitly selected indicators with the SDGs (Criterion 5). Sixth, these tools incorporate participatory mechanisms that support stakeholder engagement and inclusive participation (Criterion 6). Finally, beyond measuring results, these tools support strategic reflection and can help orient collective action. In particular, the Indicators Toolbox for Measuring Progress in Sustainable

Food Cities (Moragues-Faus & Marceau, 2018), through its structured framework built around six levers of change, helps make visible the structural conditions shaping transition pathways and identify areas where targeted action is needed. These levers include partnerships and collaboration, policies and strategies, infrastructure and planning, public support and services, knowledge and awareness, and market mechanisms.

However, as mentioned above, tools covering a larger number of components and indicators may require greater human, financial, and time resources. In addition, LFSs addressing Indigenous food issues may require complementary tools such as the Food Sovereignty Assessment Tool (First Nations Development Institute, 2014). In contrast, the Food Policy Audit (O'Brien & Cobb, 2012) covers 18 components and uses a binary (yes/no) response format, making it more accessible in contexts of limited resources. However, its limited depth requires complementary qualitative inquiry to better understand the underlying factors shaping both strengths and challenges. In sum, given that sustainability components cannot all be equally adapted to every local context, tools should be selected based on clearly defined local priorities, available capacities, and strategic objectives.

Study Limitations

This review has two main limitations. First, we included only assessment tools designed for community, municipal, or regional scales. National or international tools that could be adapted to local contexts were excluded, with the exception of multiscale frameworks such as SAFA and the CRFS Toolkit, which were retained due to their explicit guidance for application across multiple governance levels. This choice is consistent with the highly context-specific nature of LFSs, but it also limits the extent to which findings can be generalized across different territories. Second, we assigned each indicator to a single sustainability component, even when it could plausibly address several. This simplification, though imperfect, prevented redundancy (Gebara et al., 2024) from diluting scores for components with fewer or less pertinent indicators and highlighted aspects requiring substantial improvement.

Conclusion

This study reveals key challenges in LFS evaluation tools and provides seven criteria to guide the selection of such tools from a socio-ecological transition perspective. These findings contribute to reframing evaluation not merely as a technical exercise, but as a transformative practice capable of generating robust, critical, and shared data that both inform action and support the shift away from the dominant conventional food systems toward more sustainable and just LFSs. The holistic assessment tools reviewed in this study have strong potential to support this transformation by stimulating collective reflection and enabling locally adapted solutions (Moragues-Faus, 2020). However, most of these tools overlook key dimensions of transition dynamics. We therefore recommend integrating a dedicated component focused on transition dynamics, with indicators to monitor structural change, such as the evolving norms, policies, and rules that support LFS innovations and the structural barriers and forms of resistance that impede their consolidation (Rabialahy et al., 2025). In addition, the selection of evaluation components should move beyond technical criteria and become a collective, strategic process involving diverse stakeholders, including vulnerable groups. This process should be guided by two fundamental questions: What are the most pressing issues in our context? And how do the selected components reflect shared priorities? Such an inclusive approach helps avoid blind spots, allows for addressing major concerns, and anchors evaluations in the lived realities of local actors. Finally, greater efforts are needed to amplify the voices of vulnerable and Indigenous populations and to create clear mechanisms for linking evaluation findings to policy-related decision-making. Strengthening these aspects is essential for ensuring that evaluation tools contribute meaningfully to systemic, inclusive, and place-based food system transformations.

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Appendix A. Adapted Taxonomy of Sustainability Component

Purpose of this Taxonomy

This taxonomy is adapted from the FAO (2014) SAFA framework and was expanded through an inductive analysis of the 22 tools included in this review. During the inductive analysis, several components and subthemes were added, expanded, or relocated to better capture the issues reflected in the reviewed tools.

These modifications are indicated using these asterisks:

* (added component and subtheme),
** (expanded component and subtheme), and
*** (relocated component).

This taxonomy served as the analytical grid for classifying indicators and identifying which sustainability issues are prioritized or overlooked across LFS evaluation tools. It supports the analytical process described in the Methods section and ensures consistency with Figure 2 and the coding strategy.

Table A. Adapted Taxonomy of Sustainability Component (C1–C24)

Dimension	Component	Subthemes
Governance	C1 – Corporate ethics (organizational ethics)	Mission statement Due diligence
	C2 – Accountability (evaluation and data use)	Holistic audits Responsibility Transparency
	C3 – Participation (citizen and stakeholder participation)	Stakeholder dialogue Grievance procedures Conflict resolution Citizen participation* Participation of vulnerable populations*
	C4 – Rule of law (policies and strategies)	Legitimacy Remedy, restoration, and prevention Civic responsibility Resource appropriation Implementation of policies and strategies
	C5 – Holistic management	Sustainability management plan Full-cost accounting
	C6 – Institutional governance*	Governance structure* Coordination mechanism*
Environment	C7 – Atmosphere (climate change)**	Greenhouse gases Air quality Energy use***
	C8 – Land and water**	Soil quality Land degradation Water withdrawal Water quality

	C9 – Biodiversity	Ecosystem diversity Species diversity Genetic diversity
	C10 – Materials and energy (consumption and waste management)**	Material use Waste reduction and disposal
	C11 – Animal health and welfare	Animal health Freedom from stress
Economic	C12 – Investment	Internal investment Community investment Long-range investment Profitability
	C13 – Vulnerability (resilience and food autonomy)	Stability of production Stability of supply Stability of market Liquidity Risk management
	C14 – Product quality and information	Food safety Food quality Product information
	C15 – Local economy	Value creation Local procurement
	C16 – Enterprise vibrancy and prosperity*	Enterprise vibrancy* Business prosperity*
Social	C17 – Decent livelihoods	Quality of life Capacity development Fair access to means of production
	C18 – Fair trading practices	Responsible buyers Rights of suppliers
	C19 – Labor rights (labor conditions)**	Employment relations Forced labor Child labor Freedom of association and right to bargain
	C20 – Equity	Non-discrimination Gender equality Support to vulnerable people
	C21 – Human safety and health (human health and well-being)**	Workplace safety and health provisions Public health
	C22 – Cultural diversity	Indigenous knowledge Food sovereignty (Indigenous food sovereignty)
	C23 – Civil society initiatives*	Civil society initiatives*
	C24 – Social capital*	Horizontal social capital Vertical social capital

* Added component and subtheme
** Expanded component and subtheme
***Relocated component

Source: Adapted from FAO (2014) SAFA framework.

Appendix B. Main Characteristics of 22 Tools Included in This Study

Table B. Main Characteristics of 22 Tools Included in This Study

Tool (Title, Author[s], Year) Country of the first author	Primary objective	Number of components assessed by dimension (Env; Soc; Eco; Gov)	Conceptual approaches and/or pre-existing tool(s) guiding development	Number of indicators analyzed*
Tools from scholarly literature				
1 – Holistic sustainability assessment method for urban food system governance (Landert et al., 2017) Switzerland	Assess and compare the sustainability of urban food system governance	22 including: (5) Gov (5) Env (5) Eco (7) Soc	• Sustainability concept • SAFA (FAO, 2014) • The Milan Urban Food Policy Pact Monitoring (MUFPP) Framework (FAO, 2015) • Sustainability Monitoring and Assessment Routine (SMART; Schader et al., 2014)	97
2 – Formes urbaines et gouvernance alimentaire (Darrot et al., 2022) France	Assess and compare urban food systems, and support local authorities in decision-making for the development of food observatories and territorial food projects (comparable to LFS initiatives)	22 including: (5) Gov (2) Env (4) Eco (3) Soc	• IDEA method (farm sustainability indicator; Zahm et al., 2008; 2019) • Landert et al. (2017) tool • MUFPP Framework (FAO, 2015; FAO et al., 2021)	70 elementary indicators organized into 28 aggregated indicators
3 – Measuring Progress in Sustainable Food Cities: An Indicators Toolbox for Action (Moragues-Faus & Marceau, 2018) United Kingdom	Develop a set of indicators to support food councils and initiatives in decision-making and in measuring progress toward sustainable food system	23 including: (5) Gov (5) Env (5) Eco (8) Soc	• Place-based and food systems approach (Moragues-Faus, 2018) • Driving force-Pressure-State-Impact-Response framework (DPSIR) (Huang et al., 2015) • SAFA (FAO, 2014) • Landert et al. (2017) tool	423
4 – Sustainable Agri-food Evaluation METHodology Framework (SAEMETH Framework) (Peano et al., 2015) Italy	Monitor small-scale agri-food systems using indicators that reflect a sustainable vision of the food system	14 including: (2) Gov (4) Env (4) Eco (4) Soc	• Sustainable food system vision proposed by the Slow Food Foundation for Biodiversity's Presidia (Peano et al., 2014)	52
5 – A sustainability scoring system to assess food initiatives in city regions (Cirone et al., 2022) Italy	Assess the sustainability of City Region Food System (CRFS) initiatives through a holistic, coherent, and user-friendly tool enabling both quantitative and qualitative evaluation	15 including: (1) Gov (5) Env (3) Eco (6) Soc	• Life cycle thinking approach (Petit-Boix et al., 2017)	63
6 – The food policy audit: A new tool for community food system planning (O'Brien & Cobb, 2012; Updated by Clark et al., 2018) USA	Identify and assess, through an objective and practical tool, the role of local actors and the relevance of local, regional, and federal food policies influencing food systems	18 including: (5) Gov (2) Env (5) Eco (6) Soc	• Advocacy Coalition Framework (Sabatier & Jenkins-Smith, 1999)	113

Tool (Title, Author[s], Year) Country of the first author	Primary objective	Number of components assessed by dimension (Env; Soc; Eco; Gov)	Conceptual approaches and/or pre-existing tool(s) guiding development	Number of indicators analyzed*
7 – Towards an impact evaluation framework to measure urban resilience in food practices (Dezio & Marino, 2018) Italy	Assess the impact and effectiveness of initiatives on the resilience of urban food systems through a holistic framework incorporating social and ecological components and implications	15 including: (3) Gov (4) Env (4) Eco (4) Soc	• Co-evolutionary paradigm (Norgaard, 1984; Kallis & Norgaard, 2010) • Impact evaluation framework to support planning and evaluation of nature-based solutions (NBS) projects (Raymond et al., 2017) • City Region Food System Indicator Framework (Dubbeling & Carey, 2018) • SAFA (FAO, 2014)	105
8 – Systemic analysis model of short food supply chains (Mundler & Laughrea, 2016) Canada	Assess the contributions of short food supply chains to territorial development	12 including: (3) Gov (2) Env (5) Eco (2) Soc	• Job satisfaction framework (Paugam, 2000)	21
9 – Sustainable food system metrics (Allen & Prosperi, 2016) USA	Develop scenarios, generate projections, and support decision-making in contexts where historical data are lacking or insufficient	15 including: (2) Gov (4) Env (5) Eco (4) Soc	• A vulnerability/resilience conceptual framework (Allen & Prosperi 2016)	139
10 – Sustainability assessment of short food supply chains (SFSC) (Doernberg et al., 2022) Germany	Measure the sustainability impacts of LFS and short food supply chains to help food system actors justify policy interventions	9 including: (–) Gov (5) Env (2) Eco (2) Soc	• A normative approach (emphasizing consumer–producer relationships; Zasada et al. 2014)	15
11 – A framework for assessing the vulnerability of food systems to future shocks (Fraser et al., 2005) United Kingdom	Assess the vulnerability of food systems at the urban scale using multiple conceptual frameworks: panarchy framework, entitlement framework, pathway theory, and portfolio theory	Not determined	• Panarchy framework (Gunderson & Holling, 2002) • Entitlement framework (Sen, 1988) • Pathway theory (Fraser et al., 2005) • Portfolio theory (Markowitz, 1952, 1959)	No indicators
12 – Territorial LCA framework for local food systems assessment (Lulovicova & Bouissou, 2024) France	Assess the environmental impacts of LFS to improve local food planning covering all activities from production to consumption within a defined geographic area	6 including: (–) Gov (3) Env (1) Eco (2) Soc	• Territorial life cycle assessment (Loiseau et al., 2013)	16
13 – URBAL (Urban Driven Sustainable Food System Innovations) (Valette et al., 2024) France	Analyze the complex interactions among actors, governance structures, and city-specific contexts in food innovation processes. Using impact pathway mapping, the aim is to identify:	Not determined	• Theory of change (Padilla, 2002; Thornton et al., 2017) • Impact pathway maps (Douthwaite, 2003)	No indicators

Tool (Title, Author[s], Year) Country of the first author	Primary objective	Number of components assessed by dimension (Env; Soc; Eco; Gov)	Conceptual approaches and/or pre-existing tool(s) guiding development	Number of indicators analyzed*
	(1) the actual changes produced by innovation in terms of sustainability; (2) how these changes are generated through innovation activities; and (3) the links between actions and sustainability, from short-term changes (outputs) to medium-term changes (outcomes) and long-term changes (impacts).			
Tools from gray literature				
14 – SAFA Sustainability Assessment of Food and Agriculture Systems (FAO, 2014) International organization	Provide a harmonized framework for assessing the sustainability along the food and agriculture value chains across environmental, social, economic, and governance dimensions	21 including: (5) Gov (6) Env (4) Eco (6) Soc	• Sustainability vision of SAFA: food and agriculture systems worldwide are characterized by four dimensions of sustainability • LCA • Based on 7 other tools aligning with a global reference framework	116
15 – Outil ATOS (Alternative Territorialized food Organisations' Sustainability) (Bouroullec & Victoria, 2014) France	Assess the sustainability of alternative food systems through an evaluation tool that supports decision-making	16 including: (4) Gov (3) Env (5) Eco (4) Soc	• Goal-oriented conceptual approach (Von Wirén-Lehr, 2001) • Holistic content-based framework (Doumenge, 1998; Rey-Valette et al., 2008)	32
16 – Community food security assessment toolkit (Cohen et al., 2002) USA	Assess the different aspects of community food security, determine the adequacy between food resources and community needs, and inform local decision-makers	7 including: (1) Gov (-) Env (2) Eco (4) Soc	• Concept, design, and implementation (Winne et al., 1997)	61
17 – Whole measures for community food systems (Center for Whole Communities, 2009) USA	Provide an overview of the strengths, weaknesses, opportunities, and threats of a food system to support strategic planning processes	18 including: (2) Gov (5) Env (4) Eco (7) Soc	• Vision for whole communities (developed by Center for Whole Communities)	69
18 – City Region Food System (CRFS) Toolkit: Assessing and planning sustainable city region food systems (Carey et al., 2018; updated by FAO, 2023) International organization	Support cities in: (1) assessing the current state and performance of a city region food system using a comprehensive approach; (2) identifying priority action areas with clearly defined desired outcomes and means to measure change; (3) planning strategies and actions to achieve those desired outcomes; and (4) establishing baselines and monitoring changes resulting from	23 including: (5) Gov (5) Env (5) Eco (8) Soc	• A whole food system approach (according to a vision for CRFS; Carey et al., 2018)	210

Tool (Title, Author[s], Year) Country of the first author	Primary objective	Number of components assessed by dimension (Env; Soc; Eco; Gov)	Conceptual approaches and/or pre-existing tool(s) guiding development	Number of indicators analyzed*
	the (future) implementation of policies and programs			
19 – Community food system assessment (Ross & Simces, 2008; updated by Sparrow, 2016) Canada	Provide an overview of the key elements of the community food system and generate information to guide decision-making, planning, policy development, and program funding	13 including: (3) Gov (3) Env (3) Eco (4) Soc	• Community Food System Assessment Guide (published by Provincial Health Services Authority, Toronto)	67
20 – Food sovereignty assessment tool (FSAT) (First Nations Development Institute, 2014) USA	Examine community food assets and inform changes aimed at improving food planning and strengthening Indigenous food systems	16 including: (3) Gov (3) Env (5) Eco (5) Soc	• Solution-oriented approach (Bell-Sheeter, 2004) • Community participatory approach (Bell-Sheeter, 2004)	94
21 – Community food project evaluation toolkit combining 6 assessment tools: (1) Common Output Tracking Form (COTF) (2) The Farmers' Market tools (3) Community Garden tools (4) Community Supported Agriculture (CSA) tools (5) Farm to School tools (6) System-Level Evaluation Tools (National Research Center Inc., 2006b) USA	(1) Accurately document and highlight the impact of Community Food Security Projects so they can use these data to improve their programs (2) Meet funder requirements (3) Contribute to the development of shared knowledge on effective community food security practices	22 including: (5) Gov (4) Env (5) Eco (7) Soc	• Basic logic model developed by United Way of America • A companion community food project evaluation toolkit	582 including 121 (Tool 1) 78 (Tool 2) 84 (Tool 3) 64 (Tool 4) 110 (Tool 5) 125 (Tool 6)
22 – Milan Urban Food Policy Pact Monitoring Framework (MUFPPMF) (FAO et al., 2021) International organization	(1) Serve as a tool to identify priorities in food-related policies and programs. (2) Illustrate the extent to which "desired changes" are occurring and the impact of those changes. (3) Assess gaps in policy advancement and resource mobilization and reveal overall improvements in urban food systems (if measured periodically). (4) Foster collaboration among municipal departments, stakeholder groups, and national governments to address food system challenges in a systematic manner.	13 including: (4) Gov (2) Env (3) Eco (4) Soc	• Food system approach • Participatory, multistakeholder approaches • Place-based approach	44

* Only the indicators effectively analyzed in this study are reported

Appendix C. List of Identified Tools and Additional Documents Reviewed to Obtain Complementary Information (e.g., Development Process, Applications, Critiques)

Table C1. List of Identified Tools

Tool #	Source information
1	Food and Agriculture Organization of the United Nations [FAO]. (2014). *SAFA (sustainability assessment of food and agriculture systems) Guidelines* (version 3.0). https://openknowledge.fao.org/items/84c84661-7172-415c-b66e-7c1eee5db675
2	Landert, J., Schader, C., Moschitz, H., & Stolze, M. (2017). A holistic sustainability assessment method for urban food system governance. *Sustainability*, *9*(4). https:doi.org/10.3390/su9040490
3	Darrot, C., Marie, M., Bodiguel, L., Hochedez, C., Margetic, C., & Pecqueur, B. (2022). PSDR4FRUGAL-Approcher les systèmes alimentaires urbains par les indicateurs: décrire, comparer, prioriser [PSDR4 FRUGAL—Using indicators to approach urban food systems: describing, comparing, and prioritizing]. *Innovations Agronomiques*, *86*, 91–105. https://doi.org/10.17180/ciag-2022-vol86-art09
4	Moragues-Faus, A., & Marceau, A. (2018). Measuring progress in sustainable food cities: An indicators toolbox for action. *Sustainability*, *11*(1), 45. https://doi.org/10.3390/su11010045
5	Peano, C., Migliorini, P., & Sottile, F. (2014). A methodology for the sustainability assessment of agri-food systems an application to the Slow Food Presidia project. *Ecology and Society*, *19*(4). http://www.jstor.org/stable/26269668 Peano, C., Tecco, N., Dansero, E., Girgenti, V., & Sottile, F. (2015). Evaluating the sustainability in complex agri-food systems: the SAEMETH framework. *Sustainability*, *7*(6), 6721–6741. http://doi.org/10.3390/su7066721
6	Cirone, F., Petruzzelli, M., De Menna, F., Samoggia, A., Buscaroli, E., Durante, E., Orsini, F., Rufí-Salís, M., Tonini, P., Durany, X. G., Graamans, L., Fargue-Lelièvre, A., Saint-Ges, V., Fox-Kämper, R., Specht, K., Pascual-Fernández, J. J., & Vittuari, M. (2023). A sustainability scoring system to assess food initiatives in city regions. *Sustainable Production and Consumption*, *36*, 88–99. https://doi.org/10.1016/j.spc.2022.12.022
7	O'Brien, J., & Cobb, T. D. (2012). The food policy audit: A new tool for community food system planning. *Journal of Agriculture Food Systems and Community Development*, *2*(3), 177–191. https://doi.org/10.5304/jafscd.2012.023.002 Clark, J. K., Marquis, C., & Raja, S. (2017). The local food policy audit: Spanning the civic-political agrifood divide. In I. Knezevic, A. Blay-Palmer, C. Z. Levkoe, E. Nelson, & P. Mount (Eds.), *Nourishing communities: From fractured food systems to transformative pathways* (pp. 131–146). Springer. https://doi.org/10.1007/978-3-319-57000-6_8
8	Dezio, C., & Marino, D. (2018). Towards an impact evaluation framework to measure urban resilience in food practices. *Sustainability*, *10*(6), 2042. https://doi.org/10.3390/su10062042
9	Mundler, P., & Laughrea, S. (2016). The contributions of short food supply chains to territorial development: A study of three Quebec territories. *Journal of Rural Studies*, *45*, 218–229. https://doi.org/10.1016/j.jrurstud.2016.04.001
10	Allen, T., & Prosperi, P. (2016). Modeling sustainable food systems. *Environmental management*, *57*(5), 956–975. https://doi.org/10.1007/s00267-016-0664-8

11	Doernberg, A., Piorr, A., Zasada, I., Wascher, D., & Schmutz, U. (2022). Sustainability assessment of short food supply chains (SFSC): Developing and testing a rapid assessment tool in one African and three European city regions. *Agriculture and Human Values*, *39*(3), 885–904. https://doi.org/10.1007/s10460-021-10288-w
12	Fraser, E. D. G., Mabee, W., & Figge, F. (2005). A framework for assessing the vulnerability of food systems to future shocks. *Futures*, *37*(6), 465–479. https://doi.org/10.1016/j.futures.2004.10.011
13	Bouroullec, M. D. & Victoria, F. (2014). *ATOS : un outil d'analyse de la durabilité des systèmes agroalimentaires alternatifs – le cas des drives d'agriculteurs de produits locaux* [*ATOS: A tool for analyzing the sustainability of alternative agrifood systems – the case of farmers' "drives" for local products*]. https://www.researchgate.net/publication/326450433_ATOS_un_outil_d'analyse_de_la_durabilite_des_systemes_agroalimentaires_alternatifs-le_cas_des_drives_d'agriculteurs_de_produits_locaux
14	Cohen, B., Andrews, M., & Kantor, L. (2002). *Community food security assessment toolkit*. Food Assistance & Nutrition Research Program. https://www.ers.usda.gov/publications/pub-details/?pubid=43179
15	Center for Whole Communities. (2009). *Whole measures for community food systems: Values-based planning and evaluation*. https://wholecommunities.org/resources-archive/whole-measures-for-community-food-systems/
16	Carey, J., Dubbeling, M., & RUAF Foundation. (2018). *City region food system toolkit: Assessing and planning sustainable city region food systems*. Food and Agriculture Organization, RUAF Foundation, Wilfrid Laurier University, & Centre for Sustainable Food Systems. https://www.fao.org/3/i9255en/I9255EN.pdf
17	Ross, S., & Simces, Z. (2008). *Community food assessment guide*. https://canadacommons.ca/artifacts/40756662/community-food-assessment-guide/41655727/
18	First Nations Development Institute. (2014). *Food sovereignty assessment tool (2nd ed.)*. https://www.firstnations.org/resources/food-sovereignty-assessment-tool-2nd-edition/ Bell-Sheeter, A. (2004). *Food sovereignty assessment tool*. First Nations Development Institute. https://www.indigenousfoodsystems.org/sites/default/files/tools/FNDIFSATFinal.pdf
19	National Research Center Inc. (2006). *Community food project evaluation toolkit*. Community Food Security Coalition. https://foodsecurity.org/CFPTOOLKIT030805.pdf
20	Food and Agriculture Organization of the United Nations [FAO], Milan Urban Food Policy Pact & RUAF Foundation. (2021). *Milan Urban Food Policy Pact monitoring framework* https://www.fao.org/documents/card/en/c/ca6144en/
21	Lulovicova, A., & Bouissou, S. (2024). Use of territorial LCA framework for local food systems assessment: Methodological developments and application. *The International Journal of Life Cycle Assessment*, 1-17. https://doi.org/10.1007/s11367-024-02289-8
22	Valette, É., Blay-Palmer, A., Intoppa, B., Di Battista, A., Roudelle, O., & Chaboud, G. (2024). *Evaluating sustainable food system innovations: A global toolkit for cities*. Taylor & Francis. https://doi.org/10.4324/9781003285441

Table C2. List of Additional Documents Reviewed for Certain Tools to Obtain Complementary Information (e.g., Development Process, Applications, Critiques)

Tool #	Additional documents
6	Pelletier, N. (2015). Life cycle thinking, measurement and management for food system sustainability. *Environmental Science & Technology*, *49*(13), 7515–7519. https://doi.org/10.1021/acs.est.5b00441
9	Clark, J. K. (2018). From civic group to advocacy coalition: using a food policy audit as a tool for change. *Journal of Agriculture, Food Systems, and Community Development*, *8*(1), 21–38. https://doi.org/10.5304/jafscd.2018.081.004
10	Allen, T., Prosperi, P., Cogill, B., Padilla, M., & Peri, I. (2019). A Delphi approach to develop sustainable food system metrics. *Social Indicators Research*, *141*, 1307–1339. https://doi.org/10.1007/s11205-018-1865-8
12	Mirzabeiki, V., & Aitken, J. (2023). Panarchy-based transformative supply chain resilience: the role of supply chain capital. *International Journal of Operations & Production Management*, *43*(1), 99–39. https://doi.org/10.1108/IJOPM-03-2022-0191
13	FAO. (2023). *Building sustainable and resilient city region food systems: Assessment and planning handbook*. https://doi.org/10.4060/cc5184en
14	Miewald, C. (2009). *Community food system assessment : A companion tool for the guide*. https://www.planning.org/knowledgebase/resource/9128540/ Martin, K., & Morales, T. (2015). *Community food system assessments* [PAS Memo]. American Planning Association. https://www.planning.org/publications/document/9121415/ Sparrow, V. (2016). *Powell River community food system assessment final report*. Powell River Food Security Project. https://prfoodsecurity.files.wordpress.com/2016/07/prcfsa_final_report_july_12.pdf
15	Whitt, O., & Pitt County Food Council Task Force. (2016, July). *Baseline assessment of Pitt County's community food system*. Pitt County, North Carolina. https://communityfoodstrategies.org/wp-content/uploads/2020/06/Pitt-County-Baseline-Assessment.pdf
18	First Nations Development Institute. (2017). *Food Sovereignty Assessments : A tool to grow healthy native communities*. https://www.firstnations.org/resources/food-sovereignty-assessments-a-tool-to-grow-healthy-native-communities/
19	National Research Center, Inc. (2006). *Community food project evaluation handbook* (3rd ed.). https://foodsecurity.org/LINK_C_Handbook_AD_pdf.pdf Chollett, D., & Naidu, P. (2009). *Kandiyohi County: Local Food System Assessment*. Center for Small Towns. https://digitalcommons.morris.umn.edu/cgi/viewcontent.cgi?article=1082&context=cst
20	Lambie, S. (2019). *Evaluating and assessing food system indicators for the city of Vancouver*. City of Vancouver. https://sustain.ubc.ca/sites/default/files/2019-59_Evaluating%20and%20Assessing%20Food%20System%20Indicators_Lambie.pdf Sibbing, L. V., Duncan, J., Arcuri, S., Galli, F., & Bock, B. B. (2022). Assessing what food policies lead to on the ground: exploring opportunities and challenges of the MUFPP indicator framework. *Agroecology and Sustainable Food Systems*, *46*(9), 1414–1439. https://doi.org/10.1080/21683565.2022.2106007

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Audited engagement: Making agri-food community development "count" in higher education and beyond

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Abstract

Community engagement is central to work in agriculture, food systems, and community development, especially within land-grant universities and extension programs. Recently, these efforts have been communicated increasingly through annual impact reports, engagement summaries, and outreach dashboards to demonstrate their relevance, accountability, and public value. This paper presents a reflective, curiosity-driven, document-based analysis of publicly available engagement and impact reports from several universities, extension systems, and related organizations involved in agri-food and community development. It explores how these reporting practices influence what is regarded as meaningful engagement. The paper introduces the concept of "audited engagement" to describe a situation where engagement is recognized and valued mainly through quantifiable indicators such as participation, reach, and activity. These indicators serve important institutional purposes: they make engagement visible to funders and stakeholders, justify ongoing investment, and shield engagement from marginalization. However, they often emphasize process over transformation. While reports document efforts such as events held, partnerships formed, and people reached, they tend to fall short of capturing structural changes, long-term redistribution, or shifts in authority, which are central to justice-oriented agri-food systems work. Instead of assessing specific programs or suggesting new metrics, the paper

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offers a conceptual analysis of how engagement is increasingly managed through reporting. This clarifies how evaluation practices shape what engagement can reasonably achieve and what remains hard to articulate.

Keywords
community engagement, agri-food systems, higher education, evaluation and metrics, institutional legitimacy

Introduction

Community engagement is foundational to work in agriculture, food systems, and community development. Land-grant universities, extension systems, and related organizations are expected not only to generate knowledge but also to work alongside communities to address complex, place-based challenges. In recent years, however, these commitments have increasingly been demonstrated through annual impact reports, engagement summaries, and outreach dashboards designed to show relevance, accountability, and public value. These documents are now a central means by which institutions communicate what engagement is and what it accomplishes (Association of Public and Land-grant Universities, 2023; Carnegie Foundation for the Advancement of Teaching, 2020). This paper examines a set of publicly available engagement and impact reports from universities, extension systems, and related organizations working in agri-food and community-development contexts, asking a simple but consequential question: what happens when community engagement is primarily understood in terms of what can be counted and reported?

I treat these institutional reports seriously—not simply as public relations artifacts to be dismissed or as transparent windows onto institutional practice, but as governance texts that actively shape how "community," "engagement," and "impact" are understood in contemporary higher education. I analyze how engagement is counted, narrated, and materially represented in these documents, and what these practices imply about responsibility, authority, and impact. These questions arise not from skepticism about engagement but from a long-standing commitment to it in agri-food and community-development work, based on my more than 25 years of experience at land-grant universities in the U.S. whose histories and missions are inseparable from promises to serve publics beyond campus boundaries. Like many scholars and practitioners in agriculture, food systems, and community development, I am deeply invested in engaged scholarship, reciprocal partnerships, and efforts to bridge the so-called town–gown divide. I have participated in, benefited from, and advocated for engagement initiatives across teaching, research, and extension. The concern motivating this paper is therefore not whether engagement matters—it does—but how it is increasingly evaluated, narrated, and stabilized through institutional reporting practices.

Annual impact reports have come to play a central role in how these institutions demonstrate their engagement to external audiences—particularly in agriculture, food systems, and rural development contexts—including funders, legislators, community partners, accreditation bodies, and the public (Association of Public and Land-grant Universities, 2023; Carnegie Foundation for the Advancement of Teaching, 2020). These documents typically emphasize reach and activity, combining quantitative indicators with brief narratives or testimonials that highlight positive experiences and outcomes. As this paper argues, however, the growing reliance on such reports does more than document engagement: it reshapes it. When engagement is rendered legible primarily through what can be counted, aggregated, and reported annually, some dimensions of community work are foregrounded while others recede. This reflects the logics of contemporary evaluation regimes, which privilege regularity and defensibility over complexity, conflict, and long-term transformation (Shore & Wright, 2015).

To capture this dynamic, I introduce the concept of "audited engagement," a term used here to describe how reporting and evaluation practices shape how community engagement is recognized and valued, primarily through countable indicators such as participation, reach, and activity. Audited engagement is neither opposed to care nor a synonym for performative engagement. Instead, it identifies a condition in which engagement is valued

most when it can be demonstrated through metrics aligned with audit practices: counts of workshops held, partners engaged, visitors welcomed, students reached, and programs delivered. These measures do important institutional and legitimizing work. They allow institutions to demonstrate responsiveness, justify investment, and protect engagement from being dismissed as marginal or anecdotal. At the same time, they shape what counts as impact in ways that have significant implications for justice-oriented work in agri-food and community development contexts.

A central claim of this paper is that impact reporting tends to privilege process (visible activities and outputs) over transformation, understood here as changes to underlying social, institutional, or material conditions. Annual reports excel at documenting what institutions do: how often they engage, how many people they reach, and how widely their activities extend. They are far less equipped to account for the structural changes that engagement produces, including shifts in decision-making authority, resource redistribution, durable institutional obligations, and redress for historical and ongoing harms. These forms of change are often slow, uneven, and contested. They resist attribution to a single program or year. As a result, they sit uneasily within reporting frameworks designed to demonstrate annual success.

Importantly, this paper does not argue that material support is absent from engagement work. On the contrary, impact reports routinely document scholarships, free programs, donated goods, subsidized services, and other tangible benefits that flow to communities. However, these forms of support are typically framed as programmatic and discretionary—evidence of generosity, innovation, or responsiveness—rather than as structural commitments or obligations. They are presented as examples of institutional character rather than as components of redistribution, repair, or accountability. This framing also resonates with work on organizational legitimation, where institutions seek to demonstrate appropriateness and value to external stakeholders through visible, standardized practices (Deephouse & Suchman, 2008; Von Billerbeck, 2023). From this perspective, the reporting of engagement activities does not merely document institutional action; it also helps secure and maintain legitimacy by aligning institutional behavior with widely recognized indicators of responsibility and responsiveness.

Impact reports are not misleading. The activities they describe and the benefits they highlight are real. Yet documenting engagement can still serve as a substitute for deeper accountability. When participation, responsiveness, and material support are rendered visible primarily through reporting, they can stand in for more difficult questions about authority, obligation, and structural change (Newfield, 2016; Urbanek, 2022). Because the conditions under which engagement would count as transformative, such as power transfer or durable institutional commitments, are rarely specified in these reports, those questions are never formally addressed. Institutions can therefore truthfully present themselves as engaged and impactful while leaving questions of who decides, who pays, and who bears risk largely untouched.

The argument presented here is intentionally modest in scope and exploratory in nature. It does not seek to evaluate the quality of specific engagement initiatives or to rank institutions by their level of commitment. Instead, it offers a conceptual analysis of a pervasive institutional logic—one that cuts across land-grant and non–land-grant universities, extension systems, and community engagement units. The documents examined consist of publicly available engagement and impact reports produced by a sample of universities, extension systems, and affiliated agri-food organizations with diverse missions, geographies, and organizational structures. While most documents originate from land-grant and public university systems, the corpus also includes materials from closely aligned organizations operating within the same institutional and funding ecosystems. Sampling was neither random nor systematic, but a curiosity-driven effort to understand how engagement is rendered legible across higher education. This approach reflects the exploratory nature of the inquiry: the goal is to identify patterns in how impact is framed, not to claim representativeness or exhaustiveness.

By focusing on impact reporting as a site where engagement is translated into evidence, this paper contributes to ongoing conversations in agri-

culture, food systems, and community development about accountability, evaluation, and justice (e.g., Gupta et al., 2018; Schiff et al., 2022). It suggests that the challenge for engaged institutions is not only to increase engagement but also to reflect critically on how engagement is measured, and on the consequences of those measurements. If engagement is increasingly central to the moral and political claims universities make about themselves, then the practices used to count and communicate that engagement deserve careful scrutiny.

The remainder of the paper proceeds as follows. The next section situates the argument within scholarship on community engagement and institutional evaluation in agri-food and land-grant contexts. I then describe the materials and analytic approach used to examine a set of annual impact reports. The core sections analyze how material support is framed in audited engagement, why process-oriented metrics dominate, and how impact reporting functions as a nonperformative form of accountability. The discussion reflects on the implications of audited engagement for justice-oriented engagement and suggests directions for rethinking what "impact" might mean beyond what is easily counted.

Community Engagement and Evaluation: A Brief Review

Community engagement occupies a central place in food systems research, land-grant traditions, and community-development scholarship (Ohmer et al., 2022; Smith & Ohlinger, 2025; Taffere et al., 2024). Across these literatures, engagement is typically framed as both a moral commitment and a practical orientation. It entails a commitment to reciprocity, responsiveness, and relevance, as well as an orientation toward knowledge production and action that emerges through dialogue with communities rather than being imposed upon them. In agriculture, food systems, and extension contexts, engagement has long been understood as a defining feature of institutional purpose rather than a supplemental activity (Reed & Swanson, 2022). Universities are expected not only to generate knowledge but to do so in ways that are accessible, applicable, and attentive to the needs and priorities of community stakeholders (Gavazzi & Gee, 2018).

Within this tradition, community engagement has been associated with a range of normative aspirations. These include strengthening relationships between universities and communities, ensuring that research and teaching address real-world challenges, enhancing trust and legitimacy, and fostering mutual learning (Ohmer et al., 2022). In agri-food systems work, engagement is often linked to sustainability, resilience, food system transformation, and community health and well-being—issues understood to require collaboration across institutional and community boundaries (Habiyaremye, 2023). Engaged approaches are often contrasted with extractive or top-down models of expertise and are valued for their greater relevance, inclusion, and responsiveness (Becerra-Encinales et al., 2024; Dangi & Yadav, 2025).

At the same time, engagement has increasingly become an object of formal evaluation. Over the past two decades, institutions of higher education have been asked by funders, accreditors, legislators, and the public to demonstrate not only that they are engaged but also that this engagement produces measurable impact. This demand has spurred the development of a growing infrastructure of assessment tools, metrics, reporting templates, and annual summaries to document engagement activities and outcomes (e.g., Hurd, 2022; Wanjiru & Xiaoguang, 2021). In land-grant and extension systems, reporting has long been a core administrative function, but its scope and visibility have expanded markedly as engagement has become central to institutional branding and accountability (APLU, 2023).

Scholarship on evaluating community engagement has generally approached this development pragmatically. Much of the literature focuses on improving measurement, identifying best practices, and refining indicators that capture the scope and effectiveness of engagement work (e.g., Hurd, 2022; Wanjiru & Xiaoguang, 2021). Common concerns include how to document partnership quality, assess learning outcomes, demonstrate community benefit, and balance quantitative and qualitative evidence. This work reflects a sincere effort to make engagement visible and valued within institutions that often privilege research outputs, which

are more readily captured by traditional academic metrics.

However, evaluation is never neutral (House & Howe, 1999). Decisions about what to measure, how often to measure it, and how to report results shape what engagement means in practice. Evaluation frameworks do not merely reflect engagement activities; they actively structure them by signaling what counts as success, what is worth investing in, and what kinds of claims can be credibly made. In this sense, evaluation functions as a form of governance, one that aligns engagement with institutional imperatives of accountability, comparability, and defensibility (Hanberger, 2012; Power, 1997).

Annual impact reports are a particularly influential expression of this evaluative logic. Produced on a regular cycle and designed for broad audiences, these reports typically aggregate engagement activities into standardized categories: participant numbers, events, partnerships, programs, volunteers, and dollars leveraged. They often pair these indicators with brief narratives or testimonials that humanize the data and illustrate positive outcomes. The resulting documents are often praised as readable, persuasive, and effective at communicating activity and reach while demonstrating transparency and accountability (Kaufer & Steponaitis, 2021).

Yet the very features that make annual reports useful also limit what they can capture. Because they are annualized, impact reports privilege forms of engagement that can be demonstrated within short time horizons. Because they are aggregated, they favor indicators that can be standardized across programs and units. Because they are public-facing, they tend to emphasize consensus, success, and positivity rather than conflict, ambiguity, or uneven outcomes. These constraints are not imposed maliciously; they reflect the institutional contexts in which reporting occurs. Nonetheless, they shape how engagement is understood and valued.

In agri-food and community-development contexts, where many challenges are structural, historically rooted, and slow to change (Kuhmonen, 2018; Nelson & Stroink, 2014), this evaluative orientation has significant implications. Engagement activities that build relationships, host events, disseminate information, or provide services are readily documented and celebrated. By contrast, changes that involve shifts in authority, long-term resource redistribution, or durable institutional obligations that unsettle traditional hierarchies are harder to make visible within annual reporting frameworks. As a result, evaluation tends to foreground process (what institutions do and how often) rather than transformation—what changes and for whom.

Normative Commitments and Evaluation Silences

A striking feature of contemporary impact reporting is not only what is named and measured but also what isn't: absences. Across many engagement reports in higher education, explicit references to power, authority, or justice are minimal, if not entirely absent. These omissions should not be read as denial or indifference. Instead, they reflect how engagement is positioned within institutional evaluation regimes that prioritize demonstrating activity and responsiveness over adjudicating normative claims.

Engagement scholarship often entails implicit normative commitments to equity, inclusion, and fairness. These commitments are evident in calls for reciprocity, respect for community knowledge, and attention to historically marginalized groups (APLU, 2023; Carnegie Foundation for the Advancement of Teaching, 2020). However, when engagement is translated into evaluative practice, particularly through annual impact reporting, these normative orientations are rarely articulated in ways that would require institutions to assess power relations, acknowledge harm, or specify obligations. Instead, these reports are often framed by indicators of participation, access, and reach, which can signal inclusivity without requiring confrontation over authority or redistribution.

This silence is analytically important. It suggests that impact reporting operates in a framework in which legitimacy does not depend on naming or resolving questions of power. Institutions can demonstrate engagement by showing they are active, present, and responsive, without specifying how decisions are made, whose priorities prevail, or how resources are allocated over time. In this

way, evaluation practices do not displace justice claims so much as render them unnecessary for institutional success.

Thus, while these reports demonstrate a level of care (e.g., events hosted, programs offered, partnerships formed, households fed) they remain largely silent on questions that would invite contestation. They routinely document redistribution through material transfers, such as scholarships, donated goods and services, and subsidized training and expertise. Yet these examples of redistribution are largely apolitical. Access to education, donated food, and technical assistance to farmers are uncontroversial because they are not efforts to provide compensation for structural harm or to change systems in ways that might introduce uncomfortable trade-offs. This silence is not a reporting failure; it is a feature of evaluation systems designed to produce coherence, comparability, and positive narratives within constrained institutional environments.

Recognizing these silences does not require rejecting engagement or its normative aspirations. Rather, it calls for closer attention to how evaluation practices shape understandings of engagement, a timely focus given that engagement is increasingly central to the identity and legitimacy of many institutions, especially those reliant on public funding. The following sections allow me to reflect more concretely on these tensions by analyzing a sample of reports from engagement-forward institutions across North America.

Empirically Anchoring My Reflections: Materials and Analytic Approach

As a reflective essay, this "analysis" is intentionally exploratory and therefore partial. The materials examined include publicly available documents produced by universities, extension systems, and affiliated agri-food organizations, including higher education consortia and community-development entities operating in these institutional ecosystems. Reflecting its curiosity-driven nature, the sample draws from institutions I have long respected for their agri-food-based community-engagement work. The focus is on annual impact reports, documents that many readers will recognize not only as sources of information but also as familiar institutional genres. I approach these materials not as neutral accounts of engagement activity, nor as comprehensive representations of what institutions "really do," but as texts that actively shape how engagement is understood, valued, communicated, and justified.

My interest in these documents is both scholarly and personal. Over the past quarter-century, I have worked at land-grant universities in roles that placed community engagement at the center of the institutional mission. At various points, I have also helped produce the very kinds of reports examined here: gathering metrics, crafting narratives, and translating complex, relational work into forms legible to administrators, funders, and public audiences. This experience informs the paper's analytic stance. The goal is not to expose shortcomings or misrepresentations but to reflect on how engagement is structured by the practical demands of reporting and evaluation.

Document-Based Analysis

The documents analyzed were selected through a convenience-based, curiosity-driven process rather than through random or systematic sampling. As someone embedded in engagement-oriented academic spaces, I encounter these reports regularly as part of institutional communications, professional networks, and routine administrative life. The sample reflects an effort to examine broadly how similar reporting logics appear across settings, rather than to identify best or worst practices.

The analysis draws on a small set of publicly available impact and engagement reports from universities, extension systems, and affiliated agri-food organizations, including consortia and centers with diverse missions, geographies, and organizational histories. Rather than treating these documents as cases for comparison or evaluation, I treat them as instances of a shared reporting genre that renders community engagement legible and accountable. Table 1 lists the documents included in the analysis along with their institutional context and stated purpose. The table is intended to provide transparency about the materials examined, not to imply representativeness or exhaustiveness.

Table 1. Impact and Engagement Reports Included in the Analysis [a]

Institution or Consortium	Report Title (Year)	Institutional Type	Primary Focus of Report	Public URL
Colorado State University (CSU Spur)	*CSU Spur Impact Report* (2025)	Land-grant university initiative	Community engagement, education, innovation, agri-food, sustainability	https://csuspur.org/wp-content/uploads/sites/6/2025/08/2025-CSU-Spur-Impact-Report-FINAL-ACS.pdf
Iowa State University Extension and Outreach	*Impact Report* (2024)	Land-grant extension system	Extension programming, agri-food systems, community outcomes	https://www.extension.iastate.edu/impact-stories/2024-impact-report
West Virginia University	*Community Engagement Impact Report* (2023)	Land-grant university	Community partnerships, outreach, institutional engagement	https://communityengagement.wvu.edu/about/impact-report
Utah State University	*Community Engagement Annual Report* (2025)	Land-grant university	Community engagement across teaching, research, and extension	https://www.usu.edu/community-engagement/files/2025_CCE-Annual-Report.pdf
University of British Columbia	*Community Engagement Annual Report* (2024)	Public research university (non–land-grant)	Community engagement, partnerships, institutional impact	https://communityengagement.ubc.ca/news/2024-annual-report
North Central Regional Center for Rural Development	*Impact Report* (2024)	Multi-institution land-grant consortium	Rural development, extension, research coordination	https://ncrcrd.ag.purdue.edu/community-development/impact-reports/
Association of 1890 Research Directors	*1890 Land-Grant Universities Impact Report* (2024)	Historically Black land-grant consortium	Extension, research, education, community impact	https://1890aea.org/application/files/7317/2186/6767/2024_1890_Land-grant_Universities_Impact_Report-FINAL-web.pdf

[a] Documents were selected as a convenience sample based on professional familiarity, public availability, and relevance to institutional community engagement and impact reporting. The table is intended to provide transparency about the materials analyzed rather than to suggest representativeness or exhaustiveness.

Analytic Focus

The analysis is qualitative and interpretive, grounded in close, iterative reading of the documents (Fairclough, 2023). My focus is not on verifying the accuracy of reported figures or assessing program effectiveness, but on understanding how engagement is framed by specific evaluative choices. Four analytic questions guided the reading:

- What is counted? Across reports, specific indicators are ubiquitous: for example, the number of participants, events, partnerships, students reached, volunteers engaged, and dollars leveraged. Attention is given to how these indicators are aggregated, highlighted, and presented as evidence of impact.
- How is engagement narrated? This includes the language used to describe relationships with communities, the use of testimonials and success stories, and the affective tone of reporting. Engagement is often framed as responsive, collaborative, and innovative, and these narratives are closely tied to the metrics provided.
- How is material support framed? Many reports document tangible benefits: free programs, scholarships, donated goods, and subsidized services. Rather than evaluating the adequacy of these supports, the analysis focuses on their positioning: for example, as programmatic offerings, discretionary benefits, or efforts to disrupt the status quo and address systemic injustices.
- How are concepts such as responsibility, authority, and inequity positioned, either implicitly or explicitly? This involves noting both what is said and what remains largely unspoken. In particular, the analysis attends to the relative absence of explicit language about power, obligation, or justice, and considers how this silence shapes what engagement can plausibly be understood to accomplish within institutional accounts.

My focus was on pattern recognition—what is repeatedly said and what is repeatedly not said—rather than institutional critique. Individual reports are neither compared nor ranked, and institutions are not evaluated against one another. Instead, the analysis highlights a shared evaluative logic that cuts across institutional contexts, making "engagement" legible through audit-friendly indicators of activity, participation, and reach.

Audited Engagement in Practice

This section examines how community engagement is translated into institutional "impact" through formal reporting practices. Rather than treating impact reports as neutral summaries of activity or aspirational statements of institutional values, I treat them as practical instruments that make engagement visible, accountable, and meaningful within institutions (Kooli, 2019; Shore & Wright, 2015). Across the documents analyzed, a consistent pattern emerges: engagement becomes legible when it can be counted, narrated, and aggregated in ways that align with audit-oriented evaluation systems. This pattern does not reflect indifference to communities or a lack of institutional care. Instead, it reflects the conditions under which universities and other organizations are increasingly asked to demonstrate responsibility.

To orient the analysis, Table 2 summarizes the recurring indicator categories used across the reports examined. The table is not intended as a comprehensive inventory or a frequency-based content analysis. Rather, it serves as an analytic aid and an empirical anchor, highlighting shared evaluative patterns across institutions and reporting contexts. These patterns provide the backdrop for the discussion that follows, which traces how engagement is understood as impact through what is counted, how material support is framed, and what remains outside the evaluative frame. By making these patterns explicit at the outset, the table allows the analysis to move beyond individual documents and toward the broader evaluative logic that organizes contemporary engagement reporting. The subsections that follow, therefore, focus on how these patterns operate and what they enable, rather than on attributing specific claims to particular institutions or tallying their frequency across documents.

Table 2. Common Indicators Found Among the Reports Analyzed [a]

Indicator Category	Examples of Metrics	Analytic Implication
Participation & Reach	Number of visitors, event attendees, students served, workshop participants	Privileges scale and visibility of engagement over depth or redistribution
Partnerships & Collaboration	Number of partners, MOUs, cross-sector collaborations	Frames engagement as relational density rather than shared authority
Programs & Activities	Events hosted, courses offered, pilot projects launched	Emphasizes activity and productivity within annual reporting cycles
Material Support	Scholarships, free programs, donated goods, subsidized services	Presents support as discretionary generosity rather than obligation
Economic & Media Impact	Dollars leveraged, economic impact estimates, media views or "clicks"	Aligns engagement with institutional value and reputational return
Satisfaction & Affect	Survey ratings, testimonials, qualitative feedback	Uses positive affect as evidence of success (as having "impact") and legitimacy

[a] This table summarizes recurring indicator types observed across the analyzed documents. It is intended to illustrate common evaluative patterns rather than provide a comprehensive inventory or frequency-based content analysis.

What Gets Counted

Across institutions and report types, impact is most often shown through indicators of participation, reach, and activity. These indicators include the number of visitors, event attendees, students served, workshop participants, partners engaged, programs delivered, and media impressions generated. These measures recur across reports, regardless of institutional mission or geographic context, providing a shared vocabulary for communicating engagement to administrators, funders, legislators, and the public.

These indicators perform important institutional work (Erkkilä et al., 2016). They make engagement visible in organizations that rely on demonstrable outputs to allocate resources and assess performance. They enable engagement units to justify their existence in increasingly competitive, metric-driven environments. They also signal responsiveness to communities by showing that institutions are present, active, and involved. Counting engagement, in this sense, is not incidental but essential to sustaining engagement in contemporary higher education and beyond.

At the same time, privileging quantifiable indicators shapes what engagement can plausibly be said to accomplish. Participation metrics foreground frequency over transformation. A well-attended event is treated as impactful regardless of whether it does anything else, thereby backgrounding questions about whether those events altered long-term relationships, redistributed authority, or changed material conditions. Similarly, the accumulation of partnerships can be celebrated as evidence of connectivity without examining how responsibility or decision-making power is distributed within those relationships.

These metrics do not misrepresent engagement, as they reflect real activities, interactions, and investments. But they also compress complex, relational work into standardized forms compatible with annual reporting cycles. What is gained is comparability, visibility, and administrative clarity. What is lost is attention to uneven outcomes, slow change, and forms of impact that resist aggregation.

Material Support That Does Not Rock the Boat

In addition to documenting participation and reach, impact reports routinely highlight the forms of material support provided through engagement activities. These supports commonly include free or subsidized programs and events, scholarships and fee waivers, donated goods or services, and reduced-cost access to facilities, expertise, or care. Their inclusion signals that engagement is not merely symbolic or relational but materially consequential.

These forms of support matter. They can lower barriers to participation, provide immediate resources, and address pressing needs. Their visibility in impact reports reflects an institutional desire to show that engagement yields tangible benefits rather than abstract goodwill. The question, then, is not whether these supports make a difference, but what kind of difference they are positioned to represent in institutional accounts of impact.

This framing has significant consequences. By treating material support as evidence of institutional character rather than institutional responsibility, impact reports remove these transfers from broader questions of accountability and structural change. Support is something institutions provide when conditions allow, not something they are required to sustain in the face of systemic injustices.

The absence of obligation language does not imply indifference to inequality or need. Rather, it reflects how engagement is situated within evaluative frameworks that reward demonstrable activity while avoiding controversial claims that would require adjudicating responsibility or harm. Material support becomes visible without becoming political. Resources move, benefits accrue, and impacts are documented, yet the underlying relations that structure access to resources remain unexamined.

This dynamic can be described as material redistribution without structural transformation. Material transfers occur, but they are framed to avoid naming justice-oriented redistribution claims. Engagement provides assistance without acknowledging extraction, repair, or redress. As a result, support is folded into narratives of responsiveness rather than into claims about justice or obligation.

Declaring Impact, Avoiding Accountability

Taken together, participation metrics and programmatic support enable institutions to make credible claims about impact. Reports can truthfully state that thousands of people were engaged, partnerships were formed, and resources were provided. These claims are not exaggerated. Yet they also function in ways that substitute documentation for accountability.

Impact reports rarely articulate the conditions under which engagement counts as transformative rather than active. Concepts such as power, authority, or justice are largely absent in these reports—not because they are rejected, but because they are unnecessary within the evaluative frame. Engagement succeeds when it can be demonstrated through auditable indicators, not by making contested claims or controversial investments.

This does not mean engagement lacks sincerity or value. On the contrary, the effectiveness of impact reporting lies in its ability to translate care into forms legible to institutional systems. By aligning engagement with audit-friendly indicators, such as those summarized in Table 2, reports strengthen legitimacy and protect engagement work from marginalization. They allow institutions to present themselves as responsive, relevant, and publicly accountable.

At the same time, this alignment limits the scope of what engagement can be expected to achieve. When impact is defined primarily by visibility, participation, and activity, engagement becomes governable in ways that favor continuity and stability over disruption and change. Responsiveness is evident, but responsibility remains diffuse. Audited engagement is therefore not indicative of failure but rather an institutional response to the demand to demonstrate impact under conditions of accountability, constraint, and risk.

Discussion: Why "Audited Engagement" Matters

The analysis presented here identifies the concept "audited engagement" as a dominant evaluative logic that shapes how engagement is understood and justified in higher education and beyond. This logic does not displace engagement or undermine its importance. Rather, it reorganizes it around forms of evidence compatible with institutional accountability systems. The significance of audited engagement lies not in contradiction (engagement versus evaluation) but in coexistence: engagement expands even as its meaning is increasingly structured by what can be counted, reported, and defended.

The concept of audited engagement helps explain a central tension in contemporary agri-food systems, land-grant missions, and rural develop-

ment efforts: the simultaneous proliferation of engagement and the persistence, and, in many cases, expansion, of structural inequities (Ostrom, 2022). Universities, extension systems, and community-facing centers are arguably more engaged than ever, as others have noted, especially as "engagement" has come to be distinguished from earlier extension models and adjacent concepts such as "diffusion," marking a shift away from linear knowledge transfer toward more relational, participatory, and place-based forms of institutional involvement (Becerra-Encinales, 2024; Carolan, 2024).

Advances in digital and hybrid infrastructures have lowered the logistical costs of convening, enabling institutions to host more events, reach broader audiences, and sustain relationships across distances (Klerkx, 2021). At the same time, the current political moment has intensified institutional focus on community engagement, particularly in rural spaces, where narratives of neglect, grievance, and disconnection have become increasingly salient (Carolan, 2020). In response, institutions have invested heavily in visible outreach—new partnerships, listening sessions, pilot programs, and place-based initiatives—designed to demonstrate presence, responsiveness, and relevance.

This expansion of engagement activity is real and consequential. More people are reached, more resources are mobilized, and more institutional energy is directed toward communities long described as underserved or overlooked. Yet this proliferation of engagement has not produced commensurate shifts in the structural conditions it is often tasked with addressing. Precarious rural and urban livelihoods, uneven access to education and healthcare, environmental exposure, and persistent inequities in the food system remain deeply entrenched, even as engagement infrastructures grow denser (Heaberlin & Shattuck, 2023; Stiernström, 2023). In some cases, these conditions have intensified alongside heightened engagement, as institutions are asked to perform more relational work.

Such work is essential, but so too are efforts to change structural conditions, which would require multiscale efforts and may entail controversial trade-offs for those who have enjoyed a certain level of positional privilege. Admittedly, this type of opportunity involves risks, as these institutions often operate at the intersection of public funding, political scrutiny, and community expectations. In such settings, the ability to demonstrate care without provoking conflict can be institutionally advantageous. Audited engagement emerges here not as a retreat from responsibility, but as a pragmatic way of managing risk—one that allows institutions to expand engagement, document responsiveness, and maintain legitimacy, while leaving more contentious questions of redistribution and authority largely unresolved.

For land-grant universities, audited engagement also reframes longstanding extension and outreach traditions. This shift does not negate the public mission of land-grant institutions, but it does alter how that mission is made legible and defensible through contemporary reporting and evaluation systems. Engagement becomes something institutions must continually demonstrate rather than something they are assumed to embody. While documenting commitment and impact annually can serve important purposes—such as protecting engagement work, securing resources, and signaling public value—it also reshapes institutional attention. Reporting practices tend to crowd out forms of engagement that are slower, less visible, or more politically contentious, and they privilege activities that can be readily narrated, counted, and aggregated.

Rethinking Impact: A Thought Exercise—No Prescriptions

Rather than offering a new set of metrics or advocating alternative reporting systems, this paper raises questions about what current definitions of impact enable and what they foreclose. When impact is defined primarily by participation, reach, and activity, what kinds of change become difficult to name? What forms of engagement resist annualization, aggregation, or attribution? And what happens to community and stakeholder needs that depend on longer temporal horizons or contested interpretations?

I ask these questions not to dismiss the value of existing evaluation practices but to situate them within the process of reporting and evaluating

"impact." Impact reporting responds to real institutional pressures and serves important protective functions for engagement work. At the same time, it shapes expectations about what engagement should entail and how success should be measured. Rethinking impact, in this sense, is less about replacing one metric with another than about recognizing the limits of metricized care.

Importantly, this is not an argument for abandoning measurement. It is an argument for attending to the consequences of measurement, particularly when measurement becomes the primary site where engagement is recognized as legitimate. Asking what impact means and who defines it is itself an act of engagement.

Limits and Openings

This paper neither offers a blueprint for more just evaluation systems nor proposes alternative indicators that could easily replace those currently in use. Doing so would risk reproducing the very dynamics under examination: substituting one set of audit-friendly measures for another.

Instead, the contribution lies in naming a condition. Audited engagement describes how engagement becomes governable through evaluation practices that privilege demonstration—visible activities and outputs—over transformation, understood as changes to underlying social and institutional conditions. Recognizing this condition creates space for reflection rather than immediate reform. It invites practitioners, administrators, and scholars to ask when engagement is being asked to do too much symbolic work and when evaluation practices might be absorbing demands that counting alone cannot resolve.

The observations presented here are intentionally reflective and document-based, but they also point toward the value of more systematic approaches to studying how engagement is rendered visible and accountable. One avenue would involve constructing a larger, comparative collection of engagement and impact reports across institutions and over time, enabling more formal coding of reporting practices, indicators, and narrative structures. Such an approach could examine how different institutional types, funding environments, and policy contexts shape what is counted and how it is presented. It would also be important to attend to variation across state and local political contexts, including differences in public investment in higher education, shifting expectations around accountability, and the degree of institutional vulnerability to external scrutiny. These dynamics may influence not only how engagement is reported, but how it is strategically framed in relation to perceived political audiences. A complementary strategy would involve triangulating document analysis with interviews and ethnographic engagement, tracing how reporting practices are produced, interpreted, and operationalized within institutions and among community partners. Together, these approaches would allow researchers to assess not only the prevalence of audited engagement practices, but also how they are shaped by, and respond to, broader political and institutional environments, with consequences for how engagement is organized, valued, and experienced in practice.

Conclusion

This paper has examined how community engagement is increasingly rendered visible and legitimate through institutional impact reporting, and how that process reshapes what engagement can plausibly mean in higher education and other engagement-centered institutions and networks. In naming the concept of audited engagement, I draw on my experience working within engagement-oriented institutions to describe a condition familiar to many in this space: engagement tends to be valued most when it can be counted, narrated, and aggregated in ways that align with audit-oriented evaluation systems.

The ways engagement is counted shape how it is understood, what kinds of claims it can support, and which forms of change remain difficult to name. For scholars and practitioners working in agriculture, food systems, and community development, this insight is especially salient. Engagement is foundational to these fields, yet the ways it is evaluated can quietly narrow its ambitions. Recognizing audited engagement as a dominant evaluative logic allows for a more honest conversation about what engagement can and cannot accomplish under current institutional conditions.

Engagement will remain a priority across pub-

lic-facing, publicly accountable institutions. At the same time, the practices used to measure and demonstrate engagement will proliferate, particularly with the growing reliance on social media and other digital outreach channels. Paying attention to how these practices organize foregrounded and backgrounded elements is therefore not peripheral to the work of engagement. It ought to be central to what we do.

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This paper is the result of more than 25 years of conversations and experiences with countless others. I've learned so much from so many.

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Municipal food systems planning in Sweden: Barriers, enablers, and the role of regional collaboration

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Abstract

Municipal food systems planning, which involves integrating different food policy areas and collaborating both within municipalities and with external food system actors, is increasingly recognized as essential for building resilient food systems. While local governments globally are giving greater attention to food systems planning, practical gaps persist and barriers to transformation remain underexplored. In Sweden, municipalities hold extensive food-related responsibilities, ranging from public meal provision and public food procurement to spatial planning, contingency planning, and the promotion of sustainable development. This provides a relevant and interesting context for examining local-scale food systems planning. Drawing on an institutionalist view, recognizing the interrelationship between structural factors and agency in planning processes taking a particular focus on

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Consent

All participants have given informed consent to participate in the research.

context, interviews and document analysis were conducted to investigate food systems planning in three Swedish municipalities. We focus on identifying key barriers and enablers, and we examine their collaborations with regional food system actors. The municipalities employed three distinct approaches to food systems planning: emphasizing local food procurement, working through food-related projects, and implementing a local food strategy. Across all cases, committed officials—whom we refer to as "food champions"—were found to be central to advancing transformative efforts. Barriers included constraints linked to regulations and limited time and resources, particularly regarding the procurement of local food. In contrast, having a local food strategy provided mandate and direction, supporting both internal and external collaboration. Project-based work enabled innovation but suffered from unstable funding and limited long-term continuity. Regional actors played a crucial role in facilitating collaborative platforms and knowledge exchange. Together, these findings emphasize the contextual interplay between structural and agential factors in advancing municipal food systems planning, and how they act as barriers or enablers. The findings highlight that in addition to developing local food strategies, local food systems identity and norms, collaborative routines, strong political support, resources for implementation, and officials responsible for coordinating food systems planning in the municipality, are key enabling factors.

Keywords
collaboration, food system, food systems planning, food systems resilience, local food strategy, local food systems, municipalities, projectification, public food procurement

Introduction

Climate change, COVID-19, and recent conflicts have disrupted global supply chains, showing that an overreliance on both global and national supply chains has increased vulnerability and food insecurity, emphasizing the potential of local food systems in decreasing the dependence on distant sources and provide food in times of crises (Ballamingie et al., 2020; Carey et al., 2021; Keegan et al., 2024). At the same time, local and regional food systems are connected to national and global flows of food and inputs, and it is not possible to provide all food locally (Blay-Palmer et al., 2018; Carey et al., 2021). In the global North, national food policy is often conducted within silos and focused on market-based and production-driven priorities (Coulson & Sonnino, 2019; Sonnino, 2019). In light of this, the local and regional scale of food systems is increasingly seen as a space for actions and collaborations (Coulson & Sonnino, 2019; Keegan et al., 2024; Parsons et al., 2021; Sonnino, 2019), with municipalities and regional food system actors highlighted by scholars as key actors in promoting food systems resilience and transformation (Carrad et al., 2022; Giambartolomei et al., 2021; Keegan et al., 2024; Moragues-Faus & Carroll, 2018). Food systems resilience includes being prepared for various shocks and crises, and being able to provide food for all (Tendall et al., 2015). Municipal food systems planning, involving integration and the consideration of different aspects of the food system, cross-departmental collaboration, and collaborations with various actors, has been described as a crucial planning approach in developing food systems resilience (Ballamingie et al., 2020; Borrelli et al., 2023; Hoey, 2022; Mansfield & Mendes, 2013).

The strong local self-government of Swedish municipalities, and the varied mandates they carry related to food systems, make them an interesting case. Their responsibilities related to food range from providing public meals in schools and preschools (including procurement of food) to spatial planning, contingency planning, and promoting sustainable development. However, there is a lack of empirical research that investigates food systems planning in Sweden at the regional and local level. While there are national survey studies (Andersson et al., 2026; Granvik et al., 2026) and a few case studies (L. Molin & Östensson, 2015; Moragues-Faus & Morgan, 2015), there has been little consideration of planning practices across different municipal departments, or the interplay and collaborations between municipal and other regional food system actors.

Municipalities can support local food systems resilience in various ways, such as by setting certain

criteria in the procurement process to promote local food production, sustainable agriculture, and healthy diets (E. Molin et al., 2024; Morley, 2021; Swensson & Tartanac, 2020); through local food community projects that can inspire collaboration between different actors and organizations and take the local context into consideration (Dawkins et al., 2024; Mansfield & Mendes, 2013; Munck Af Rosenschöld & Wolf, 2017); and through local food strategies integrating food across policy areas and enabling collaborations (Morgan, 2009; Sonnino, 2016; Zerbian & de Luis Romero, 2023). Finally, while there has been a growing interest in food systems planning from local governments around the globe, there are still gaps in practice (Hoey, 2022), and empirical examples of challenges and opportunities are lacking (Sonnino et al., 2019; Vignola & Oosterveer, 2025). Therefore, this study aims to contribute to filling this gap by drawing on an institutionalist view on planning (Calderon & Westin, 2021). The study was guided by the question: How do contextual factors shape food systems planning in three Swedish municipalities, and what are the main barriers and enablers in such work?

Regional and Local Food Systems Governance in Sweden

Sweden is considered a well-developed and egalitarian welfare state, where food insecurity has generally been low relative to the global level (Rost & Lundälv, 2021). Sweden's food systems governance operates across multiple territorial levels, involving national, regional, and local actors. The European Union (EU) influences work at the national, regional and local scale, particularly through the Common Agricultural Policy (CAP), which sets objectives for agricultural development and provides funds for agriculture and rural development (European Commission, n.d.), and the EU directive on public procurement (Directive 2014/24/EU). Sweden is divided into 21 counties and regions, and 290 municipalities. Counties and regions represent similar geographical areas, and in this article, 'regional' refers to both the county and the region geographically, although there are separate administrative bodies for counties and regions. Within each county, a county administrative board (CAB) represents the state and is responsible for ensuring that national objectives are implemented in ways that reflect regional conditions (The Government Offices of Sweden, 2020). The CAB has a responsibility to implement actions according to the national food strategy. There are regional food strategies in all counties (The Ministry of Rural Affairs and Infrastructure, 2025). At the regional scale, another institution led by elected politicians is the regional council which works with matters such as food provision for hospitals. At the regional level there are also regional food business organizations who support business development in the food sector (Gröna kluster Sverige, n.d.). These types of organizations often receive funding from municipalities, CABs and/or regional councils.

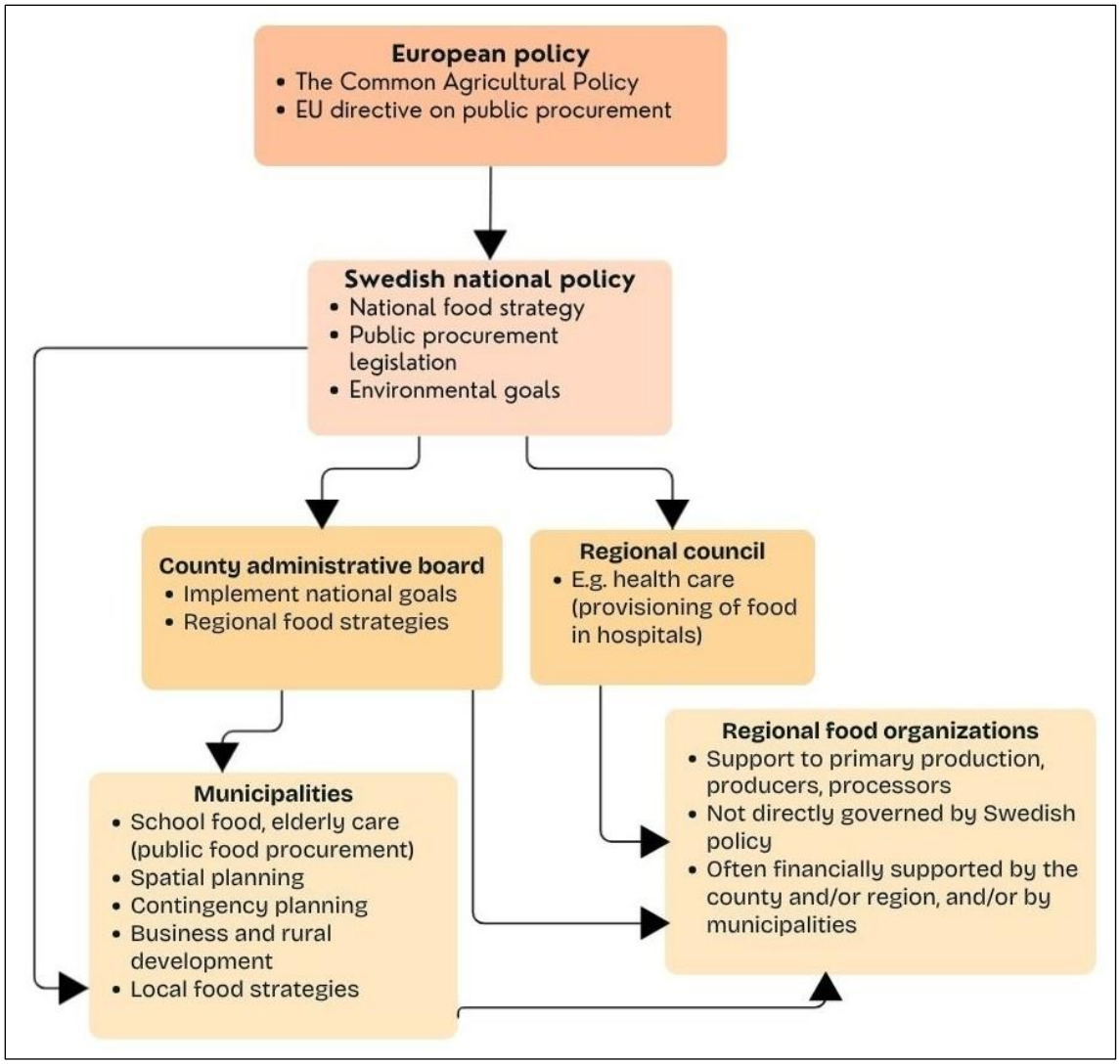
Municipalities mainly operate at the local scale, but they are guided by regional strategies as well as national laws and guidelines. They are run by locally elected politicians (The Government Offices of Sweden, 2020) and have a high level of autonomy to formulate goals or strategies (Dawkins et al., 2024) and adapt these to the local context (Erlingsson & Ödalen, 2017). Different responsibilities related to food are dealt with at different municipal departments, including public meal planning, procurement, business development, rural development, and contingency planning. There are other local and regional food organizations and nongovernmental organizations (NGOs) in Sweden, but this study is limited to actors who were perceived as main collaborators to the case municipalities. Figure 1 illustrates the above described governance structure.

Food Systems Planning

In this study, food planning at the local level is considered as both strategic and operative work carried out by municipal officials at different departments. Drawing on Morgan (2009), we define food planners as all municipal officials who work to strategically plan and/or coordinate different aspects of the food system. Food systems planning concerns working with food planning from a systems approach, both strategically and in practice (Hoey, 2022; Morgan, 2015). This entails considering food as complex systems consisting of many

actors, factors, and activities like the environment, institutions, inputs, infrastructures, and more, to how we produce, process, market, and consume food (Ericksen, 2008; Zurek et al., 2022). Defining food as a system enables taking the interconnected relationships between factors into consideration, in turn facilitating more integrated policy mechanisms (Arthur et al., 2022; Blay-Palmer et al., 2018). Starting from a consideration of local food systems as city-region food systems (CRFS): "a complex network of actors, processes, and relationships involved in food production, processing, marketing, and consumption within a geographical region of an urban center and its surrounding peri-urban and rural hinterland" (Arthur et al., 2022, p. 1288), where food system processes are understood through place-based and contextual factors, offers a potential to incorporate such a systems lens (Arthur et al., 2022; Blay-Palmer et al., 2018; Sonnino & Milbourne, 2022). In sum, in combining CRFS and food systems planning, this study focuses on the need for both localizing food systems and working with food planning from a systems approach in order to promote food systems resilience and transformation (Keegan et al., 2024; Sonnino et al., 2019).

Figure 1. A Non-Exhaustive Illustration of Food Systems Governance in Sweden, Providing an Overview of Governing Authorities with Arrows Showing how they are Connected



Analytical Framework: An Institutionalist Approach to Planning

In order to explore food systems planning in municipalities, this study draws on communicative planning theory (CPT), which is informed by an institutionalist approach highlighting the relational aspects of planning (Calderon & Westin, 2021; Healey, 1997, 2003). CPT is partly built on the notion of structuration, which sees structures and agency as interactive (Giddens, 1984; Healey, 1997). Drawing on Calderon and Westin (2021), this study focuses on the "interplay between institutions and agency" (p. 15) where institutions are seen as shaped by contextual and complex formal regulations and procedures, and informal norms and routines that influence planning processes and act as barriers or enablers to what planners and other stakeholders can do within these processes. At the same time, actors have certain agency to decide what actions to take, which can either reproduce existing structures or change them (Calderon & Westin, 2021). Calderon and Westin (2021) suggest institutional factors (*norms, regulations* and *routines*), and agency factors *understandings, values, resources* and *relationships*), to analyze the influence of context in planning processes. In this study, these are complemented with and exemplified by drawing on studies in food systems planning.

Norms are informal rules guiding and legitimizing certain ways of acting and behaving; for example, the norm may be hierarchical structures or collaborative approaches. *Regulations* are legislation or written guidelines that specify planning practices (Calderon & Westin, 2021). They could be international or national policies or laws influencing local food systems planning (Béné & Abdulai, 2024; Dawkins et al., 2024), or local food strategies (Morgan, 2009; Sonnino, 2016). Food systems planning literature states that leadership from higher governance levels is important in making decisions such as national food policies and goals (Béné & Abdulai, 2024; Dawkins et al., 2024). *Routines* are the regular and embedded everyday practices employed by individuals and organizations in planning processes (Calderon & Westin, 2021), which in a municipal context could be the usual way of working in departmental silos (Baldy et al., 2021; Grundel & Trygg, 2024) or adapting the organization to a project-based form of work (Fred, 2020; Jacobsen, 2022). *Understanding* considers the knowledge that actors have about the issue at hand (Calderon & Westin, 2021); in this case, whether the actors understand food as a complex system (Sonnino, 2023), as well as their understanding of collaborative processes. *Values* are the motivations and attitudes of actors (Calderon & Westin, 2021); for example, whether there are individuals who are committed to food issues (Dawkins et al., 2024; Hoey, 2022). *Resources* are both material and human resources available in the planning process (Calderon & Westin, 2021). Political will, staff, and financial resources have been noted as crucial in developing food system strategies and projects (Carey, 2013; Doernberg et al., 2019; Vara-Sánchez et al., 2021). *Relationships* can be both interpersonal relationships and stakeholder relationships (Calderon & Westin, 2021). Collaboration between a diverse set of actors such as municipalities, farmers, businesses, and NGOs are considered key in fostering solutions to food system challenges (Carey, 2013; Morgan, 2015; Zink et al., 2022).

Methods

In this study, we present case studies from three Swedish municipalities. Case studies can give detailed, contextual knowledge and a comprehensive understanding of complex issues in a real-world setting (Yin, 2018). Document analysis and interviews were used as empirical data to explore food systems planning at the local and regional level. Interviews were also conducted with representatives from county administrative boards (CABs) and regional food organizations in the three regions. Regional actors were included to obtain an understanding of food systems planning at the regional level and to explore how these actors collaborate and interact with municipalities. Regional actors were identified by the case study municipalities as key collaborators and as influential stakeholders shaping food systems planning at the regional level. The analysis was based on the institutionalist approach described above and the factors *norms, regulations*, *routines*, *understandings, values, resources* and *relationships* were operationalized to

analyze the specific context shaping food systems planning in three Swedish municipalities and how these factors act as enablers or barriers.

Case Studies

The three municipalities were chosen through information-oriented selection, choosing cases that were believed to be information-rich and considered as frontrunners in municipal food systems planning in Sweden (Flyvbjerg, 2006; Patton, 2015). A limitation of case studies is the difficulty of generalizing findings to other contexts; still, as information-rich and as frontrunners, we consider these case studies as able to provide insights valuable to other contexts as well. Municipalities were selected based on responses they submitted to a survey study conducted in a larger research project that explored municipal food systems planning, in which they stated that they are engaged in supporting local food systems and exhibited some degree of collaboration. The selection strategy sought variation in population size and urban–rural context, recognizing that these factors shape municipal preconditions, organizational structures, and resource capacities. Accordingly, one small rural municipality and two larger urban municipalities were included, with an additional aim of ensuring representation from different counties (Table 1; Figure 2).

In all cases, a representative from the CAB was interviewed. In Värmland, an employee from the regional food organization Nifa was interviewed. Nifa's goal is to support food sector businesses in Värmland with such efforts as business development and networking. In Västra Götaland and Östergötland, the regional food cluster organizations Agroväst and Vreta Kluster were interviewed who focus on development mainly for primary producers, with one key aim being to promote collaboration between food system actors within their region and to promote different projects.

Figure 2. Map of Sweden with Three Case Study Municipalities and their Respective Counties

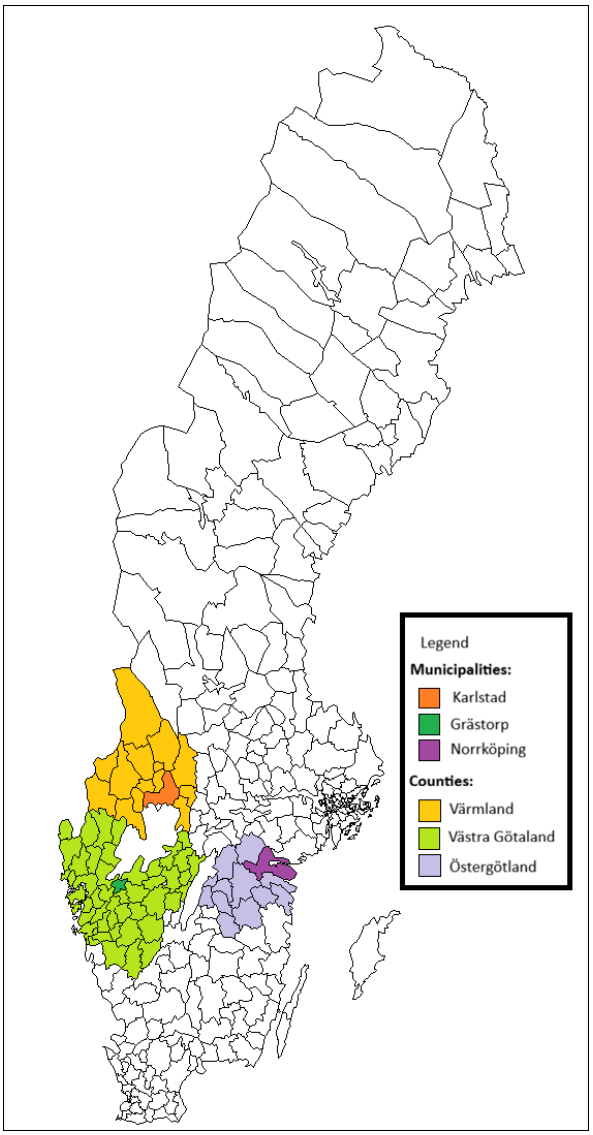


Table 1. Characteristics of the Three Case Study Municipalities

Municipality	Population	Rural population (%)	Agricultural land area (%)	County
Karlstad	98,000	10	19.5	Värmland
Grästorp	5,600	46	58	Västra Götaland
Norrköping	145,000	8.5	26.3	Östergötland

Source: The municipalities in numbers: https://kommunsiffror.scb.se/

Interviews

In each municipality, the first author conducted semi-structured interviews during 2023 and 2024 with non-elected officials from different departments responsible for food-related issues. The interviewees were selected on the recommendation of the official who had responded to the survey and/or was identified as the person working strategically with food systems. For the CABs, officials working with the regional food strategy were chosen, and at the regional food organizations, interviews were conducted with employees with extensive knowledge about the overall work of the organization. See Appendix A for a full list of interviewees. The interview questions aimed to explore how municipal officials and regional actors work to promote resilient local food systems, how they collaborate, and what they perceive as barriers and enablers in their work and why. The municipal interview guide (see Appendix B) was formulated based on the study's aim and background. For the regional actors, separate interview guides were used adapted to their context (see Appendix C). The interviews lasted around one hour and were carried out either face-to-face or online. All interviews were audio recorded and one of the authors transcribed the interviews in full.

Steering Documents

We analyzed steering documents such as plans, policies, or strategies that related to food in each municipality to some extent. These documents guide decision-making and describe issues and solutions. As such, they provide useful information on how the municipalities work with issues around food. We found the documents by searching the municipalities' websites. See Appendix D for a full list of documents. The documents provided information and insights about the case studies and were used as inspiration for the interview guide, as well as to complement and verify findings from the interview data.

Analysis

Qualitative text analysis was used to analyze both the steering documents and the interviews. This method entails reading the texts carefully with the research questions and relevant literature in mind, highlighting key terms, concepts, and passages (Kuckartz, 2014). In a first step, the data was coded using NVivo. The research questions and reviewed literature on food systems planning were used as a starting point to arrive at initial codes. Starting with this deductive approach ensured that the coding reflected important topics and issues related to the research (Skjott Linneberg & Korsgaard, 2019). While reading the document and interview transcripts, codes were changed or added if additional interesting themes were found, enabling us to stay open to different interpretations of the data while at the same time remaining close to the theory and background of the study (Skjott Linneberg & Korsgaard, 2019). A complete codebook can be found in Appendix E. After this initial sorting, the coded segments were grouped into themes: local food, food preparedness, climate change/environment, governance, barriers, enablers, internal collaboration, and external collaboration. This allowed for the analysis of different themes from the interviews and documents. This data was then sorted into *norms, regulations*, *routines*, *understandings*, *values*, *resources*, and *relationships*, according to the analytical framework.

Results

This section presents the main results from the three case studies.

Karlstad: Dedication to Procure Local Food

In Karlstad, a main focus was to procure local food for the meal services offered by the municipality. Existing regulations such as the Meal policy states that the municipality should aim to procure locally produced food, defined as food produced in Värmland county, and that small and medium-sized companies should be encouraged to submit bids for procurement contracts (or *tenders* in European terminology). However, there is no formalized and quantifiable goal for this. Environmental and climate issues related to food were highlighted in several steering documents. For example, the Meal policy had a goal regarding the amount of organic food procured in the public organizations. There was an aim to reduce climate impact from food by serving more vegetarian food and reducing food waste.

A strong focus on procuring local food for the municipal meal services was noted by four of the municipal interviewees, largely driven by the work of one committed official. This has been a focus since 2013, when this official, the head of public meal planning in high schools, started working in the municipality. The procurement of local food is a close collaboration between the public meals services departments and the procurement department in the municipality. In regards to relationships, this collaboration was said to work well and facilitate the procurement process.

Considering resources, the officials reported experiencing support from local politicians for the aim to procure local food. Still, as one respondent pointed out, politicians did not increase the budget for procurement. Another relationship aspect was the central part of the approach to procure local food through establishing a close collaboration with farmers. As illustrated by one of the interviewees, this has enabled the municipality to ask for products suited to the municipal organization, e.g., packaging size or organic products, and in exchange the municipality promises to buy their product(s):

> You can ask the producer to change their product to suit us [the municipality] better. Regarding price, size, packaging, and quality. This cannot be done with someone who is further away because the connection is broken. This provides an added value, more than just a product, it is a service connected to a product. (KI_3)

In relation to understandings, one interviewee stated that having knowledgeable staff who are committed to promoting local food systems is essential, which has also been a key enabler in establishing collaborations. For example:

> I think that a key factor is that we have people in our organization who are passionate about this and push it forward. I think that is absolutely a key factor in this case. Especially when the political direction is not that clear. (KI_4)

Another challenge mentioned related to routines was that farmers find it complicated selling to the municipality, and some already have long-term agreements with market-dominant and large-scale food co-operatives. Three respondents mentioned the Swedish Public Procurement Act as a regulation barrier since this law prohibits municipalities from buying locally if above a certain sum. There were ways to work around it, however. For example, Karlstad municipality asked producers to visit schools to talk about their product(s) (and therefore they needed to be within a two-hour distance from the municipality). Officials also stated that they had to make the case to local politicians for buying locally, since such products are normally more expensive than conventional foods. One such argument was that the municipality could support local businesses.

A resource in the county of Värmland is a wholesaler who provides food from local producers around the region, which was said to facilitate procuring local food for the municipality. As interviewees explained, the local wholesaler has also enabled producers to grow new products such as plant-based proteins, involving the municipality as a buyer of that product, creating security for the farmer. A norm that was mentioned was the regional interest in local food, and the importance of Nifa, a regional food organization, as a resource:

> They [Nifa] support locally and regionally produced basic food commodities and products. So Nifa is very important for the development of the local food supply chain in Värmland. (KI_5)

Additional relationships were described by the Nifa and CAB interviewees. The interviewee from Nifa said that they have supported municipalities to adapt procurement in order for smaller businesses to be able to submit tenders. This has led to 12 out of 16 municipalities in the region procuring local food. The CAB interviewees mentioned a project led by their organization that aimed to highlight the importance of locally produced food in school meals and strengthen local food production. The project included study visits to farms for schoolchildren, chefs, and politicians as a way to increase the understanding of where and how food

is produced. Karlstad municipality was one of the collaborators in the project, and one of the staff responsible for school kitchens worked part-time on the project, which created a close collaboration between the municipality and the CAB. One barrier mentioned by the CAB interviewees was the regulation and routine of working on short-term projects with short-term funding, making it difficult to work strategically and with a long-term perspective. Applying for projects and doing administrative tasks was said to be time-consuming.

Grästorp: Agricultural Identity and Collaboration Through Projects

In Grästorp, in the county of Västra Götaland, the main approach to food systems planning was through two EU-funded projects, establishing a temporary routine of working with food issues through projects. Grästorp's identity as an agricultural and rural municipality became evident in both the interviews and when analyzing steering documents. The steering documents also provided regulatory means to promote food systems resilience. The Comprehensive plan stated that the municipality should protect agricultural land, and several documents (Comprehensive plan, Goals for environmental work, Meal policy, Development plan) stated that local food production should be supported. The Meal policy stated that locally produced food should be encouraged in the procurement process and that the municipality should have preparedness for three weeks in the event of a crisis. The Goals for environmental work included goals to reduce food waste and minimize climate impact from public meals, such as by procuring organic food and serving more vegetarian food.

Project documents and one interviewee outlined the municipality's two food system projects, which have provided resources to work with food issues focused on increasing local food production and processing, sustainability, preparedness, and collaboration. The first project started in 2019. Farmers were provided support from the municipality to test the production of plant-based proteins in an attempt to explore both what could be grown locally and how locally grown food could be consumed locally. The second project lasted between 2023 and 2025. In this project the municipality again worked with farmers and experimented with new crops that could potentially strengthen the resilience of the local food system. The project also explored if residual flows from local food industries could be used to create new foods by local small-scale processors. Lastly, the project developed a "crisis-product" to be used during crises, composed of local food.

In relation to understandings and values, knowledgeable officials and local politicians who are committed to the issues were mentioned by the municipal interviewees as important enablers in promoting local food systems in Grästorp. One interviewee reflected on the lack of a local food strategy, making actions related to food quite dependent on officials' interests. Still, both officials and politicians wanted to keep Grästorp's strong identity as an agricultural and rural municipality; as one interviewee explained:

> There is political will and interest in the rural community in Grästorp because it is such a large part of Grästorp's municipality and history. But I think it is also because of the strong initiatives from officials who are passionate about these issues and who have seen the opportunity to apply for funding for these types of projects, so I think it is a combination. (GI_2)

However, more clarity from politicians was also asked for by one of the interviewees:

> There is ambiguity and insecurity around who should do what and how much, the level of ambition. Those are the biggest problems. If it had been clear—we are supposed to do this—then it would have been easy. (GI_4)

Another challenge was making the whole food chain local; a lot of food is produced in the municipality, but there is a lack of local processors and packaging companies. This has led to an understanding of the need to work beyond the municipal organization and collaborate with other actors regionally. One goal in the second project was to find ways to include processors. Illustrating this, one interviewee said:

> We lack the processing step in our municipality … local food is bigger, it goes beyond the municipal borders. … We need to collaborate with other municipalities around us in order to contribute to short and secure food supply chains. (GI_7)

In both projects, relationships have been crucial, and interviewees remarked that the aim was to collaborate with a variety of actors. The second project included seven municipalities, businesses, farmers, local food organizations, and researchers. From the municipalities, officials from different departments participated. The projects provided knowledge exchange and network events with a strong focus on learning, increasing the understanding of food systems issues. Agroväst, the regional food cluster organization, acted as a communications platform to share the knowledge gained in the project between different actors. The interviewee from Agroväst said that at the regional level, they work to share and transfer knowledge between actors.

Collaboration in various forms was mentioned by all interviewees as necessary for working with complex issues like the food system, and two stated that once relationships are established, it is easier to collaborate in the future. The interviewee from the CAB described leading a project about local food in public meals, supporting municipalities to procure local food, and creating opportunities for producers, municipalities and wholesalers to meet and discuss. Additionally, this person explained that projects such as those in Grästorp illustrate how municipalities are beginning to move beyond their traditional services, by supporting local producers and strengthening food preparedness:

> They work with talking to the primary producers or considering the distribution in the municipality. Or bigger issues, than just their own operations so to say. (VG_1)

While the projects have provided resources and opportunities for collaboration and working with food systems, concerns regarding working in projects were also raised in relation to what happens when the projects end and the lack of resources that might follow, illustrated by one of the interviewees:

> It is important with these projects where you get dedicated funds for personnel resources. But it is also important to think about how we can implement it in the permanent organization. … Perhaps there is a risk. I won't say that it will be completely deprioritized, but simply that there will not be enough time and personnel resources to keep it going. (GI_6)

Norrköping: Political Will and a Local Food Strategy

In contrast to the other municipalities, Norrköping in the county of Östergötland has developed a local food strategy. It was initiated by local politicians and finalized in 2022. As a regulatory framework, the strategy is at the core of the municipality's food systems planning, including a broad range of policy areas such as agricultural land, environmental issues, procurement of local food, food preparedness, and supporting local food businesses. In other documents, agricultural land (Comprehensive plan, Knowledge base document agricultural land, Overall goals and goal fulfillments 2023-2026) and agricultural businesses (Direction for rural policy) are recognized as important for preparedness and sustainable food supply. Organic and locally produced food should be promoted in procurement processes (Guideline for food and meals, Guideline for public meal services, Guideline for procurement and purchases).

One municipal interviewee explained the municipality's work with the local food strategy in more detail. In contrast to the regular process, where officials develop strategies, this interviewee explained that they had aided in the drafting of the strategy, and that the politicians were highly involved in this process. The strategy contributes to clarifying the role of municipal officials, provides mandate, and shows a clear political will for working with food system issues, also by providing financial resources:

> We have chosen to develop a strategy. … In addition, 4 million (SEK) has been delegated

> to reach the goals of the food strategy and the meal policy … and a politician has been appointed as responsible for the local food strategy. That shows political will and that the questions are prioritized. (NI_3)

The strategy promotes building relationships and has enabled new collaborations between different municipal departments and with external actors. For example, there is a project to collaborate more closely with producers and other local food businesses, according to a municipal employee:

> I think it [the strategy] is good, because then we have one more platform. And a chance to really discuss with external parties who will be affected by it. … We often say that the best steering mechanism for the food issue are the municipal steering documents. (NI_3)

In relation to personnel resources, the employee (NI_3) is now responsible for coordinating the implementation of the strategy, from an understanding that it is of value to have officials from different municipal departments involved in the process, as well as external actors. The interviewee explained that this type of role is rare in Sweden: it is usually officials at the public meal services department who work with food, but they only have responsibility for the municipal food services. They might not have the knowledge or resources to work with food strategically or connect it to other issues.

One focus area in the strategy was procurement of local food, in relation to which interviewees mentioned regulatory and routine barriers such as local food being expensive and the difficulty of receiving tender submissions. Another regulatory barrier mentioned by three interviewees was the Public Procurement Act. Action at the national level to change the act would be beneficial, two interviewees argued. It was stated to be easier to procure organic food since that can be added as a requirement in the tender, while this is not possible for local food.

In regards to relationships, interviewee NI_3, the CAB, and Vreta Kluster mentioned a regional collaborative group coordinated by the CAB, working strategically with food. For example, they have developed an action plan for the regional food strategy, as well as key indicators to measure if actions are met. Vreta Kluster supports innovation and development for primary production, in turn increasing food production in Östergötland, which contributes to fulfilling the strategy. The CAB remarked that the regional collaborative group enables knowledge exchange between actors, building connections, and helping each other, aiding implementation of the strategy. The group consists of three municipalities (of which Norrköping is one), as well as other actors from the regional food supply chain. They also arrange workshops and similar events to spread the knowledge to other municipalities in the region. While it was stated by the CAB interviewee that broad collaboration both in developing and implementing the strategy has been essential, concrete action is still difficult due to a lack of regulations and resources from the national level:

> Ten years have gone by, and we have not reached much further. However, much is due to the lack of clarity in assignments (from the national level), with no connection to funding. (Ö_1)

The interviewee from Vreta Kluster explained that they organize a network for all of the heads of public meal planning in the municipalities in Östergötland, where they can learn from each other and collaborate around, for example, procurement of local food. The network is a way for Vreta Kluster to understand the needs and interests of the municipalities, organize meetings or projects around those topics, and involve other relevant actors in such processes. This interviewee expressed that working on projects provided a common space to meet, while more long-term resources in the form of financing and assignments from municipalities, businesses or other organizations could ensure continuity, flexibility and lower the administrative burden of projects.

Cross-Case Analysis

Table 3 provides a comparison between the factors: norms, regulations, routines, agency, under-

standings, values, resources, and relationships, in the three municipalities. This illustrates similarities and differences between them, which are further explored in the discussion.

Discussion

The results showed that work with food systems planning in the three case study municipalities is shaped by different contexts. In a decentralized state such as Sweden, where municipalities have relatively high autonomy, it is not surprising that municipalities take different approaches. One benefit of such a system is that actions can be adapted to the local context, while a downside might be that certain issues are not prioritized due to the lack of interest from local politicians and officials. Especially considering food systems planning, where conducting food system projects in the local community or developing food system strategies are not a requirement, it is reasonable that actions and initiatives will vary from place to place and often become dependent on individual food champions.

In the studied municipalities, the various interests, resources, and knowledge of food champions can be one explanation for differences in

Table 3. Contextual Factors Influencing Working with Food Systems Planning in the Three Case Study Municipalities

Factors	Karlstad	Grästorp	Norrköping
Norms	• Interest in supporting local food in the region • Food from a systems perspective not a prioritized policy area	• Strong local food and agricultural identity in the municipality • Agriculture a prioritized policy area	• Interest in supporting local food in the region • Food from a systems perspective is a prioritized policy area
Regulations	• Steering documents • Public Procurement Act • Lack of clarity from national level • Lack of clarity/mandate from local politicians	• Steering documents • Public Procurement Act • Lack of clarity from national level • Lack of clarity/mandate from local politicians	• Steering documents • Public Procurement Act • Local food strategy • Lack of clarity from national level • Mandate from local politicians
Routines	• Working in silos	• Working in silos, except for projects	• Coordinator gathering officials from different departments
Understandings	• Officials are specialized in their area	• Food systems understanding from one official. Other officials more specialized in their area	• Food systems understanding from one official. Other officials more specialized in their area
Values	• Official committed to local food procurement • Politicians with interest in local food	• Official committed to food system issues • Politicians with interest in agriculture and local food	• Politicians and official committed to food system issues
Resources	• No additional staff or budget for local food procurement or other food issues • Local wholesaler	• Projects creating resources to work collaboratively and systemically • No additional staff or budget	• Staff and budget for implementing both meal policy and local food strategy
Relationships	• Partly collaboration between departments • Collaboration with local farmers to increase procurement of local food • Regional actors coordinating collaborations	• Cross-departmental and external collaboration in the projects • Lack of working across policy areas outside the projects • Regional actor as communications platform	• Local food strategy enabling cross-departmental and external collaboration • Regional actors coordinating collaborations

approaches. In both Karlstad and Grästorp there is no local food strategy, and there is a lack of financial and personnel resources for working with food systems, showing a lack of leadership and clear regulations. In both cases, committed officials whose values and understanding support food systems, have been crucial in taking actions despite these institutional barriers. This study reinforces that such food champions have a key role in promoting action and establishing collaborations (e.g., Carrad et al., 2022; Giambartolomei et al., 2021; Hoey, 2022; Milestad et al., 2026). However, relying heavily on people's personal motivation and commitment risks exhaustion (Giambartolomei et al., 2021), and losing a food champion can result in the loss of collaborations, in turn limiting food systems transformations (Dawkins et al., 2024). Moreover, such food champions might not exist in all municipalities.

Another explanation for the differences between the municipalities can be local identity and local political economy. In the case of Grästorp, the local agricultural identity and close contact with local farmers can explain why the municipality chose to focus on projects that could enable concrete actions for farmers rather than a food strategy that might not lead to direct action and implementation. In the county of Värmland, where Karlstad is located, there is a strong interest in food-related issues. This was also identified as a motivating factor for Karlstad, reflecting a well-established norm of engaging with food issues. In contrast, Norrköping's approach can be explained by a beneficial local political economy with regulations in the form of a politically developed local food strategy accompanied by both financial and personnel resources, providing a mandate and direction for municipal officials to work from a systems approach. A dedicated official holds a coordinating role for the local food strategy, which has been pointed out as significant in previous studies (Mah & Thang, 2013; Minotti et al., 2022; Sibbing & Candel, 2021). This illustrates the importance of both committed officials and politicians having values that support food systems planning, as well as an understanding of food systems complexity. These factors reduce the likelihood that efforts on local food systems will cease if a food champion were to leave. This shows that committed political leaders who support the ideas of food champions in practice are critical in providing resources and formally mandated regulations (Carrad et al., 2022). The local food strategy has also enabled collaborations between departments in the municipal organization involving different policy areas in implementation, as well as with external actors, creating a norm of working collaboratively, which could enable a systemic approach. However, our results challenge the emphasis on local food strategies in creating coordinated action. In Grästorp and Karlstad, having food champions and a sense of political support has led to considerable action. This adds additional nuance to the role of local food strategies in relation to other factors such as local identity, political will, support to food champions, as well as establishing local governmental staff positions centered on local food systems (Berglund et al., 2021, p. 88). At the time of this study, the implementation of the local food strategy in Norrköping had just started and it was not clear what outcomes the food strategy will lead to and whether the outcomes would be more beneficial than those in Karlstad or Grästorp.

In Karlstad, the work has mostly been focused on procuring local food, mainly due to the interest and commitment of one official, with the norm of working in departmental silos staying intact. This indicates a lack of a systems approach where different aspects of the food system are taken into consideration (Andersson et al., 2026). Still, an increase of local food production could strengthen preparedness, and the close collaboration with farmers could encourage organic agriculture. However, while Sweden has been pointed out as a country with good opportunities for procuring local food (Stein & Polychronakis, 2024), this study reveals strong structural barriers in the form of regulations, namely the Public Procurement Act, reinforcing previous findings (Adamson et al., 2026; Granvik, 2012; Granvik et al., 2026; Milestad et al., 2026). According to the Swedish Public Procurement Act (SFS 2016:1145), which is informed by the EU directive on public procurement (Directive 2014/24/EU), it is normally not allowed to specify local food, or even Swedish food, as a requirement in the tender, but encouraging smaller and local

producers to answer the tender is allowed. Another barrier is the reliance on the two biggest national wholesalers in procurement (E. Molin et al., 2024; Stein & Polychronakis, 2024), which means that the norm and routine is to buy from them. Karlstad has access to a local wholesaler, which facilitates the procurement of local food in the Värmland region. However, such possibilities are not available everywhere in Sweden. In summary, even though individual interests can lead to an increase of local food procurement and the establishment of collaborations with farmers, there are regulations, norms, and routines, as well as a lack of resources, strongly inhibiting local food procurement. Changes to the Public Procurement Act and national goals could facilitate procurement of local food, but such a change has to be made at the national or EU level, since EU policy affects goals and laws set at the national level. Still, municipalities can raise these issues to higher governance levels.

In Grästorp, the projects show a higher capacity to work from a systems approach, as shown by a broad involvement of different actors and a focus on different food policy areas such as local food, food security, and environmental issues, and recognizing the relationships between them. This was partly due to the understanding and value of food systems of one committed official who initiated the projects, with the support of local politicians. The projects have enhanced the understanding of food systems through regular meetings and knowledge exchange. The projects had a clear focus on beneficial relationships through the collaboration of many actors, both within the municipal organization and externally, since this was considered crucial in being able draw a comprehensive picture of the food system and to find solutions, which is in line with previous research (e.g., Adamson et al., 2026; Arthur et al., 2022; Berglund et al., 2021; Carrad et al., 2022). The lack of local processing and packaging that was identified in the first project led to an understanding and focus in the second project on targeting local processing businesses as collaborators in the project. This can be seen as an attempt to include the often "missing middle" in the collaborative effort, potentially enabling a more systemic food systems approach, rather than focusing on primary production and consumption (Sonnino et al., 2019). Grästorp reflects a norm and routine of projectification in public planning (Jacobsen, 2022; Munck Af Rosenschöld & Wolf, 2017), where interviewees stated an uncertainty as to what impact the projects will have in the long term, which is consistent with previous research showing that initiatives are scaled down or shut down when the project is finalized (e.g., Jacobsen, 2022). Several of the regional actors also mentioned the struggle of working in projects and the lack of possibility of working strategically over the long term due to a lack of resources. Projects were seen as administratively burdensome, having unstable funding, and only lasting for a short time. Other studies have also seen that the end of project funding can lead to the end of collaborations and partnerships, in turn limiting the potential for long-term change (Dawkins et al., 2024). This reliance on short-term initiatives risks undermining the continuity and institutionalization of food systems planning and collaborative efforts, limiting their long-term effectiveness in shaping resilient local food systems. In the case of Norrköping, where a strategy has been developed, this suggests a more long-term commitment to the issue. At the same time, the projects in Grästorp have been a way to create a routine of working collaboratively and provided extra resources for working with food systems planning, challenging the traditional norms and routines of working with food through sectoral silos with limited opportunities for collaborating closely with other actors and testing and developing new initiatives. This raises a potential conflict between the long processes of developing strategies and promoting more direct action through projects. Future studies could further explore the relevance of developing food strategies versus other approaches such as projects.

Furthermore, in all the case studies, it became evident that enabling values of regional food organization and the CABs as committed and motivated to local food systems are essential in creating arenas for beneficial relationships between different food system actors, increasing the understanding of food system issues, and in turn strengthening a systems approach to food planning. This is an example of vertical governance

between the local and regional levels, creating coherence between governance scales, which is one key aspect in promoting food systems transformation (Béné & Abdulai, 2024). Previous studies have shown a lack of vertical collaboration, creating knowledge gaps and limiting a systems perspective (Sonnino et al., 2019). In our case studies, these regional collaborations enable actions from production to consumption, as well as supporting public procurement of local food, possibly offering an avenue into a systemic approach.

This study poses the localization of food systems as a potential strategy to promote more resilient food systems. However, this presupposes that everyone should have access to food at all times. Previous studies have found structural injustices, for example, that people with low income or ethnic minorities do not have the same access to locally produced food (Allen, 2010; Enthoven & Van den Broeck, 2021). One of the examples in this study, of municipalities increasing procurement of local food to preschools and schools, might offer an avenue into considering some social justice issues (Allen, 2010), especially in Sweden, where nutritious school food should be provided free of charge (SFS, 2010:800). Previous research has also found that including marginalized groups and actors with oppositional viewpoints in collaborative efforts is lacking (Manganelli, 2020; Sonnino, 2023), and that dominant actors often are favored (López Cifuentes et al., 2026). It is also likely that people within the local community will have different opinions (Allen, 2010; Borrelli et al., 2023) and planners will probably have to deal with trade-offs between various desires and needs (Zurek et al., 2022). There is also a risk that powerful actors steer which issues or aspects are prioritized (Allen, 2010). For example, when municipalities hold the power of who is included or not, their perceptions of who to include or when highly shapes the collaborative processes (Brons et al., 2022). Therefore, the question concerning who has access to local food and who gets to participate and how in collaborative efforts is important for municipalities to consider. With increasing rates of food insecurity in Sweden (Rost & Lundälv, 2021), aspects of justice and inclusion are increasingly becoming central to food planning processes. Future studies could explore dimensions of food justice in Swedish food systems planning since this is an understudied topic (Rost & Lundälv, 2021).

In summary, one main contribution of this study is to show how highly dependent food systems planning is on each specific context and how the interplay between institutional and agential factors influences this. Another key finding is the vital role of relationships and collaborations in enabling a systems approach to food planning. One limitation of this study is that it is based on three case study municipalities, which might limit the understanding of contextual factors shaping planning in other municipalities. Considering that these municipalities were identified as frontrunners in food systems planning, we can assume that there would be both similar, different, and even additional barriers in municipalities working less intensively on these issues.

Conclusions

Drawing on an institutionalist view, this study analyzed the contextual factors shaping food systems planning in three Swedish municipalities, including barriers and enablers they face in such work. First, while national regulations and norms influence the municipalities in similar ways, local and regional factors lead to distinct opportunities for promoting food systems planning. The results demonstrate that food systems planning is highly context-dependent and shaped by an interplay between institutional structures and individual agency. While Sweden's decentralized system of governance allows municipalities to tailor approaches to local conditions—due to differences in local resources and needs, political priorities and economic resources—it also leads to different developments of food systems initiatives across municipalities.

Second, the results further show that across all cases, committed officials—"food champions"—were found to be central in ensuring that initiatives are taken and advanced. They play a critical role in fostering collaborations, particularly in contexts where formal local food strategies, resources, and political mandates are lacking. However, this reliance on individual actors raises concerns regarding continuity, scalability, and long-term resilience. The comparison between the three cases highlights that

no single approach guarantees effective food systems planning. Formalized strategies, as seen in Norrköping, can provide direction, legitimacy, and institutional stability, enabling a systemic and coordinated approach. At the same time, the cases of Karlstad and Grästorp illustrate that action can emerge in the absence of a food strategy, driven instead by local food champions, identity, political support, and project-based initiatives. These findings challenge the assumption that local food strategies are critical for coordinated actions, suggesting instead multiple pathways to food systems transformations. Nevertheless, structural barriers (particularly regulations such as public procurement legislation), limited time and resources, and entrenched institutional norms continue to constrain municipalities' ability to implement systemic approaches. Project-based work, while valuable for experimentation and collaboration, often lacks continuity and risks undermining long-term impact if not institutionalized. This tension between short-term initiatives and long-term strategic planning remains a central challenge.

Third, the results also underscore the importance of multilevel governance and collaboration. Regional actors play a key role in facilitating knowledge exchange and coordination across sectors and scales, supporting a more integrated approach to food systems planning.

Overall, this study contributes to the understanding of both structural conditions and human agency in the local context. It highlights the need for balancing flexibility with institutional support, short-term action with long-term commitment, and efficiency with equity. Future research could further investigate comparative effectiveness of strategies versus project-based approaches, as well as explore the role of justice and inclusion in shaping sustainable and resilient local food systems.

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Appendices

Appendix A. Interviewees

Table A. Number of Interviews in Each Case Study, Identifier Codes, and Their Municipal Department or Organization

Municipality and date of interviews	Identifier code	Municipal department or organization
Karlstad, May 2023	KI_1	Spatial planning
	KI_2	Business development
	KI_3	Head of public meal planning
	KI_4	Procurement
	KI_5	Rural development
	KI_6	Contingency planning
February 2024	V_1	County Administrative Board (2 interviewees)
March 2024	V_2	Nifa (regional food organization)
Grästorp, October 2023	GI_1	Spatial planning
	GI_2	Local government head
	GI_3	Contingency planning (2 interviewees)
	GI_4	Public meal planning
	GI_5	Head of public meal planning
	GI_6	Head of spatial planning
	GI_7	Business and rural development
April 2024	VG_1	County Administrative Board
April 2024	VG_2	Agroväst (regional food organization)
Norrköping, May 2024	NI_1	Spatial planning
	NI_2	Procurement
	NI_3	Head of public meal planning
	NI_4	Business development
	NI_5	Sustainable development
	NI_6	Contingency planning
	NI_7	Food safety
November 2024	Ö_1	County Administrative Board
October 2024	Ö_2	Vreta Kluster (regional food organization)

Appendix B. Interview Guide for Municipalities

Introduction: Go through information about the project and personal data, etc., and make sure they consent to handling of data (see separate document information sheet for interviewees).

Explain what we mean by local food systems and that we will analyze from a resilience perspective:

By local food systems, we mean activities within a defined geographical area (the region) that affect the production, processing, distribution, trade, preparation and consumption of food. The system contains many different actors. It includes different areas such as preparedness, agricultural land, local food and the environment. Resilience is a broad concept, which can be said to deal very broadly with vulnerability and the ability to handle and respond to crises. For example, natural disasters, climate change, war, or pandemics. To analyze from a resilience perspective, we will look at certain factors that are mentioned in the research as important for resilient local food systems. Among other things, the importance of local and environmental issues, to be prepared for crises, to have good collaboration, and opportunities for learning.

All questions concern how you work in your municipality. We have chosen your municipality because the answers in the survey showed that you are already working with these issues to a certain extent.

Background questions

- What is your role in the municipality?
- How long have you worked in the municipality?

1. **In the survey, the municipality answered that you have worked to promote local food systems for X years. Can you describe this work? How have you been working?** Those who did not participate and answered the survey, do they agree? Depending on what they cover and don't cover, ask questions about, e.g., agricultural land, local food, food security, environment/climate and food. For example, if local food and organic go together. Ask them about specific projects.

2. **In the survey, the municipality replied that there is political will to work on promoting local food systems. In what ways? What is done in practice?** Those who did not participate and answered the survey, do you agree?

3. **What are the main reasons the municipality works to promote local food systems?**

4. **Besides political will, are there other factors enabling the municipality to work with local food systems? Something that is absolutely central?** Ask in what way it is an enabling factor.

5. **If you have encountered barriers in your work to develop local food systems, what have been the main ones?** What are the obstacles? What are the biggest challenges now/going forward? Follow up/depending on answer: lack of national support/national instruments, lack of cooperation externally (with neighboring municipalities and/or other actors), lack of resources in the municipality (budget, personnel)

6. **Would you say that there is a holistic policy/holistic thinking (around local food systems) in the municipality that permeates all administrations and encourages working with local food systems?**
   - What does this look like in practice?
   - Is there a strategy in which these questions come together? Advantages/disadvantages of this?
   - Is there an opportunity for competence development and learning around these issues? Workshops, trainings etc.

Now there will be 3 questions about cooperation/collaboration. First, I will ask about how you work internally, then with neighboring municipalities, and then with other actors.

7. **Can you describe how you collaborate around local food systems within the municipality?**
    - How does it work in practice? What has the process leading up to this been like? What conditions have there been for cooperation?
    - How have you worked to find synergies between different issues and administrations?
    - Is there a call from politics to cooperate? How?
    - Are there obstacles? Goal conflicts? What works well, what can be improved?
    - Need for more collaboration? With other administrations? Does it need to be developed? Around what?
    - Has the collaboration helped you? How?
    - Are there routines or functions that enable coordination and collaboration in the form of regular meetings or collaboration forums where food issues can be discussed?

8. **Can you describe how you collaborate on local food systems with neighboring municipalities?**
    - Joint strategy, with whom? What is included? Purpose/goal? What should be done? If not, is it needed?
    - How does it work in practice? What has the process leading up to this been like? What conditions have there been for cooperation?
    - Is there a call from politics to cooperate? How?
    - Are there obstacles? Goal conflicts? What works well, what can be improved? Need of more collaboration?
    - Has the collaboration helped you? How?
    - Are there routines or functions that enable coordination and collaboration in the form of regular meetings or collaboration forums where food issues can be discussed?
    - Are there weaknesses/strengths based on your similar/different conditions that you can help to collaborate on? Do you have similar problems or not?
    - Is there a need to cooperate with other municipalities that you do not cooperate with today? Which? Why?

9. **Can you describe how you collaborate on local food systems with external actors?**
    - Joint strategy, with whom? What is included? Purpose/goal? What should be done? If not, is it needed?
    - How does it work in practice? What has the process leading up to this been like? What conditions have there been for cooperation?
    - Is there a call from politics to cooperate? How?
    - Are there obstacles? Goal conflicts? What works well, what can be improved? Need of more collaboration?
    - Has the collaboration helped you? How?
    - Are there routines or functions that enable coordination and collaboration in the form of regular meetings or collaboration forums where food issues can be discussed?
    - Is there a need to cooperate with other actors that you do not cooperate with today? Which? Why?

10. **The municipality answered in the survey that you are interested in taking a leading role in strengthening collaboration between neighboring municipalities and external actors to develop local food systems. Do you agree? How do you see that role?**
    - How can this happen? What are the conditions? What is the main task in such work?
    - What is your vision in taking a leading role?

11. **How do you see the work to develop local food systems going forward? Are there possibilities to be able to realize it?** What would facilitate or enable this, any specific conditions that would be needed?

Conclusion

Is there something I missed, something you want to add?

Do you have any questions?

Talk about the process going forward: how we move forward; might we see you again for a meeting about the continuation of the project?

- Do you have a suggestion for something we can focus on going forward in the project? Your needs?
- How could we proceed with a workshop?
- It is also fine if you respond via email later.

Appendix C. Interview Guides to Regional Actors

Interview Guide for County Administrative Boards

Can you tell us a little about your role at the County Administrative Board and how long you have worked there?

1. **How do you see the County Administrative Board's role in implementing the national food strategy?**
   - How is it done in practice? Projects?
   - How is it financed?

2. **How did the process go about developing the regional food strategy?**
   Has the strategy given you the conditions to work with regional food systems and if so, in what way? What advantages do you see in having a strategy? (if you see advantages)

3. **How do you see the role of municipalities in implementing the national/regional food strategy?**

4. **What do you think is needed for Sweden to have more resilient food systems?**
   - Who are the main actors in this?
   - What is the role of the County Administrative Board? How can you contribute?
   - What is the role of the municipalities? What responsibilities do they have?
   - What do you consider to be the main obstacles to being able to develop resilient food systems in Sweden?
   - What do you consider to be the main conditions for being able to develop resilient food systems in Sweden?

5. **How do you work with food preparedness?**
   Is this new for you to work with? What is the role of the County Administrative Board in this?
   How do you view the concept of food security?

6. **Do you collaborate with municipalities to promote resilient food systems? If yes, how?**

7. **Do you collaborate with other actors to promote resilient food systems? If yes, how?**
   With whom? Also, with other authorities?

8. **Are issues around agricultural land, food preparedness, and local food addressed in a coherent way in your work on promoting resilient food systems? Do you see connections between these areas? If so, in what way?**

9. **Can the County Administrative Board in any way influence municipalities' preservation of agricultural land for food production? How?**
   Is there any such discussion?

10. **What do you think are the main measures that Sweden needs to take to strengthen its food supply capacity?**

Conclusion

Is there anything I have missed, something you would like to add?
Do you have any questions?

Interview Guide for Regional Food Organizations

Can you tell us a little about your role at X and how long have you worked there?

1. **Can you tell us a little about what X is and why it was started? What is your main purpose?**

2. **What kind of actors are part of the organization?**

3. **How do you define local food? Is there a common definition for local food?**

4. **Can you tell us a little about how you work more concretely? How is your work organized? Do you promote local food systems? If so, in what way?**
   - Specific things/areas that you focus on?
   - In projects? (who is involved in the projects, why these projects in particular) Strategy? Working method?
   - Do the members collaborate with each other in any way?

5. **Do you collaborate with municipalities on local food systems? If so, in what way?**

6. **Do you collaborate with any other actors in the county? If so, in what way?**

7. **Do you take the regional food strategy into account in your work? Were you involved when it was developed? Do you also relate to the national one?**

8. **Are there specific preconditions that help you in your work to support resilient local food systems?**

9. **If you have encountered challenges in your work to support resilient local food systems, what have been/are the main ones?**

Conclusion

Is there anything I have missed, something you would like to add?
Do you have any questions?

Appendix D. Steering Documents

Swedish municipalities can to some extent choose what type of documents to develop, so they do not necessarily have the same titles in different municipalities. Therefore, exactly the same documents have not been analyzed in each municipality, but we ensured a comprehensive set of documents were sourced for each case.

Table D. Steering Documents Analyzed in Each Municipality

Municipality	Documents and year
Karlstad	Procurement policy (2015)
	Strategic plan (2022)
	Guideline: Public meal services in preschools, schools, and youth recreation centers (2022)
	Comprehensive plan (2012)
	Comprehensive plan 2050 (not adopted)
	Environmental and climate strategy (2013)
	Food policy (2013)
	Knowledge base document agricultural land for comprehensive plan 2050 (n.d.)
	Meal policy (high schools) (2008)
	Green structure plan (2021)
Grästorp	Business strategy (2016)
	Comprehensive plan (2016)
	Guiding document 2020-2024 (2021)
	Strategy for rural development (2014)
	Goals for environmental work (2015)
	Meal policy (2022)
	Policy for procurement and purchases (2018)
	Project presentation (2023)
	Project report (2023)
	Development plan (2020)
Norrköping	Guideline for food and meals (health care) (2022)
	Comprehensive plan (2023, not adopted)
	Guiding document for environmental policy (2017)
	Direction for business development (2021)
	Direction for rural policy (2020)
	Guideline for procurement and purchases (2023)
	Knowledge base document agricultural land (2021)
	Guideline for climate adaptation (2020)
	Guideline local food strategy (2022)
	Guideline for public meal services (2021)
	Overall goals and goal fulfillments 2023–2026 (2021)

Appendix E. Codebook

Table E. Codes Used for the Inductive and Deductive Coding of Interview Transcripts and Documents

Deductive codes	Definition and selection	Examples
Agriculture and agricultural land	Everything related to the use and value of agricultural land in the municipality, as well as other references to agriculture	"Agriculture has long been an important industry and remains so today."
Barriers	Things mentioned as barriers in the interviews or things that can be interpreted as a barrier to developing local food systems or to collaborations, etc.	"Challenges, yes. It's the procurement, of course. It's the Public Procurement Act."
Climate change	Specific references to food or agriculture in relation to climate change	"We need a different type of agriculture than what we have today. And there is almost no one who knows what that means. I often ask the question, what does agricultural change mean based on climate change?"
Collaboration	Statements or sections mentioning collaboration within the municipality or with other actors	"Information and training opportunities offered for interested suppliers and producers. Opportunities for dialogue can advantageously take place in collaboration with other municipalities and external actors."
Enablers	Things mentioned as enablers in the interviews or things that can be interpreted as enablers to developing local food systems or to collaborations, etc.	"From a political perspective, I find it very clear that it is important that we also try to promote local agriculture and farming and that industry."
Environment	Specific references to food in relation to environmental issues	"Eating habits also have a major impact on health and the environment."
Local food	Mentioning of local food, locally produced food, urban farming, local consumption of food, local food systems	"… testing growing alternative crops and protein sources. To simply develop the food supply and for food consumption."
Resilience	If this specific word was used in interviews or documents	"… which in turn is an important function for a more resilient agriculture."
Inductive codes	**Definition and selection**	**Examples**
Business sector	Things related to businesses and the business sector within agriculture and food	"There is an interaction between the business sector, green industries, to create these contact points with the producers."
Governing	Things around participation, trust, information, and how they govern. Who is committed. Goals and strategies related to food.	"That politicians make certain decisions. It provides control and guidance that can be, or is absolutely crucial, I would say."
Learning	Things related to learning, knowledge, and understanding of food systems, opportunities to learn about food and food systems	"It is those officials who happen to have interest and knowledge who drive but there is no coordination."
Preparedness	Mentioning of food preparedness, food security, measures to be prepared in case of crisis	"So that is about us being able to have a storage that has both food and water, or access to heat and other things to be able to … as a preparedness for our residents, but also primarily our own services."
Procurement	Things related to the public procurement process of food	"In order to give local companies a greater opportunity to participate in the procurement, the municipality must be creative in the requirements specifications to seek to find new opportunities to give local small businesses the chance to participate."
Rural development	Food and agriculture mentioned in relation to rural development, or possibilities to work and live rurally	"Norrköping has a vibrant countryside where agricultural land is an important part of supplying the municipality with local food."
Sustainable development	If this specific word was used in interviews or documents	"The plan's proposals should support positive and at the same time long-term sustainable development in the municipality."

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Navigating the nexus of food, energy, and ecology: Foodshed approaches for integrated land use policies

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Abstract

Increasing competition for land among food and feed production, renewable energy, settlement expansion, and ecological restoration creates a pressing policy challenge in many regions. Diets, farming practices, and food loss and waste jointly shape land demand and greenhouse gas emissions, while decisions on bioenergy versus wind and photovoltaic deployment affect both land availability and climate outcomes. Yet existing foodshed frameworks rarely integrate energy system alternatives and carbon sequestration potentials into a single scenario-based assessment. This study addresses that gap by extending the Metropolitan Foodshed and Self-sufficiency Scenario (MFSS) framework to quantify trade-offs across the food-energy-ecology nexus. The MFSS's primary contribution lies in embedding renewable energy land-use modeling, greenhouse gas accounting, and carbon sequestration estimation into a single comparative scenario framework, moving beyond self-sufficiency assessment toward integrated analysis.

We apply this extended MFSS framework to the governmental district of Lower Franconia (Bavaria, Germany). Building on region-specific yield data and consumption patterns, we quantify per-capita and aggregate land footprints, theoretical

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self-sufficiency rates, and surplus land available after meeting a 100% regional food supply threshold. Beyond prior MFSS applications, we allocate remaining land to renewable energy production (bioenergy crops, photovoltaic, wind) and carbon sequestration via conversion to potential natural vegetation, while estimating greenhouse gas emissions across diets and farming systems.

Across 24 scenarios combining four dietary patterns (baseline omnivorous, flexitarian, vegetarian, vegan), two production systems (conventional, organic), and food loss and waste assumptions, dietary shifts and waste reduction strongly reduce land footprints and expand surplus land for renewable energy and ecological restoration. Organic scenarios require more land due to lower yields but exhibit lower management-related emissions per hectare. Bioenergy crops cannot meet regional primary energy needs with available land, whereas wind and photovoltaic can satisfy regional energy demand while preserving substantial areas for carbon sequestration and biodiversity.

The framework offers governance-relevant opportunities for municipalities and food system actors seeking integrated, place-based land-use strategies that align food self-sufficiency, energy transitions, and climate performance.

Keywords
regional land use, scenario development, land footprints, energy production, emissions, communities, policymaking

Introduction

Global agriculture faces significant pressures that challenge global food security, including climate change, biodiversity loss, population growth, and competing land uses (Searchinger et al., 2018). Climate change alters growing seasons and reduces productivity (Clark et al., 2020), while biodiversity decline diminishes ecosystem services (Weiskopf et al., 2024). Population growth intensifies competition for limited agricultural land through urban expansion, energy production from renewables, and conservation, though pressures vary by country, depending on development level and land-use policies (Akmal & Mohammadi, 2025; Dong et al., 2021).

Dietary choices influence health and environmental sustainability (Springmann et al., 2018). Current food systems account for around one-third of global anthropogenic greenhouse gas (GHG) emissions (Crippa, Solazzo, et al., 2021), driven by lifestyle and diet (Ritchie et al., 2018). In Central Europe, the food system is responsible for 47% of GHG emissions (Crippa, Guizzardi, et al., 2021). Rising consumption of animal-based and processed foods increases land, water, and energy use (González-García et al., 2018; Halpern et al., 2022; Li et al., 2024; Meier et al., 2014; Ritchie et al., 2018; Röös et al., 2017; Treu et al., 2017; Vicente-Vicente, Doernberg, et al., 2021; Willett et al., 2019), with beef production requiring approximately 15 times more land than grains or vegetables (Poore & Nemecek, 2018; Treu et al., 2017). Despite the growing popularity of plant-based diets in high-income countries, global meat consumption continues to rise (FAO, 2025).

Food waste further influences environmental impacts (land, water, etc.), as roughly one-third of food produced globally is lost or wasted, leading to resource inefficiencies and emissions (Gustavsson et al., 2011). In Germany, 14-20% of food-related GHG emissions stem from food loss (Eberle & Fels, 2016). The United Nations Environment Programme (UNEP) estimates that 931 million tons of food are wasted annually (UNEP, 2021). Despite efforts to tackle food waste at the consumer level, effectiveness remains limited due to complex, context-specific factors, such as purchasing behavior. Waste reduction is therefore crucial for mitigating environmental burden (Beyer et al., 2022).

Land use contributes to climate change as both a carbon source and sink (Searchinger et al., 2022). Agricultural practices affect soil carbon stocks, with methods like agroforestry, conservation tillage, and organic farming offering potential for carbon sequestration and reduced emissions (Crippa, Solazzo, et al., 2021; Erhart et al., 2015; Halpern et al., 2022; Hülsbergen et al., 2022; Willett et al., 2019). Yet, alternative land-use options, such as reforestation and natural vegetation, can achieve even higher carbon sequestration rates and support biodiversity (Fehrenbach & Bürck, 2022).

Organic farming presents an alternative to conventional agriculture due to its systemic approach,

despite lower yields (in Bavaria and Lower Franconia, around 55% of conventional yields) and higher land use per unit of food produced (de Ponti et al., 2012; Joseph et al., 2019; Panday et al., 2024; Sanders et al., 2025; Vicente-Vicente & Piorr, 2021). While limited globally (1–2%), organic farming is prominent in Germany (11% of agricultural land) (Willer et al., 2024), highlighting ongoing debates on the extent to which organic and conventional methods can be integrated to simultaneously meet growing food demand, reduce environmental impacts, and promote sustainability objectives (Meemken & Qaim, 2018; Muller et al., 2017; Seufert & Ramankutty, 2017).

Energy production on agricultural land remains contentious due to trade-offs between bioenergy crops and food production. Miscanthus and similar bioenergy crops can mitigate such conflicts, especially on marginal lands (e.g., in Brandenburg, Germany) (Ben Fradj et al., 2016; Tavakoli-Hashjini et al., 2020). However, renewable energies such as wind and solar photovoltaic (PV) demonstrate higher energy output per land area compared to bioenergy crops (Böhm, 2024; Nitsch et al., 2012; Yin et al., 2024).

Thus, dietary choices, food waste, and organic farming practices influence the allocation of agricultural land for food and/or energy production. This creates trade-offs that affect the composition, availability, and distribution of food within regional food systems.

In Germany and across the European Union (EU), the Common Agricultural Policy (CAP) plays a key role in shaping the availability and distribution of food within regional food systems. Pillar I supports farm income and production capacity through direct payments, indirectly affecting food availability; Pillar II promotes rural development, agri-environmental schemes, organic farming, and regional value chains. The EU *Farm to Fork Strategy* complements the CAP by advancing sustainable food systems, shorter supply chains, and stronger producer-consumer links (European Union, n.d.).

Regional food systems are increasingly studied as socioecological systems that integrate production, processing, distribution, and consumption within a defined geographic area, emphasizing local economic linkages, social equity, and environmental sustainability over long-distance supply chains. They offer promising solutions for food security and rural development, as highlighted by disruptions from COVID-19, geopolitical conflicts, and climate events (Barrett, 2020; Kaufmann et al., 2022; Sylla et al., 2022; Tavakoli-Hashjini et al., 2020). Shortening supply chains and strengthening actor relationships can improve food security, adaptive capacity, and social cohesion at the community scale, fostering trust through direct producer-consumer connections and local value-adding activities, although benefits vary widely with context and supply chain characteristics (Enthoven & Van Den Broeck, 2021). Robust regional networks, supportive infrastructure, and multistakeholder governance are crucial for resilience and scaling up (Keegan et al., 2024). Beyond resource efficiency, regional food systems strengthen local capacity to shape food provisioning, retain regional value, and advance food sovereignty. Our research elucidates how dietary change, agricultural systems, waste reduction, and renewable energy adoption influence local action opportunities, including public procurement, community-supported agriculture (CSA), value chain coordination, and biodiversity-oriented land stewardship.

Several foodshed analyses have evaluated regional self-sufficiency capacity and demonstrated the importance of regionalized food production in reducing emissions and strengthening community resilience. In 2019, Zasada et al. developed the MFSS model to estimate the agricultural area required to feed four European cities. The term "foodshed" refers to the land needed to produce food for a specific population. An overview of European foodshed analyses is provided in Appendix Table A1.

Previous foodshed studies have primarily focused on self-sufficiency and agricultural practices, occasionally incorporating food waste or bioenergy as isolated additions. Critically, no prior MFSS-based application has simultaneously allocated surplus land across renewable energy alternatives and carbon sequestration scenarios or systematically compared their climate and land-use implications across a full factorial scenario matrix combining dietary patterns, farming systems, and food waste assumptions. This fragmented approach overlooks

how food production, energy generation, and environmental objectives interact and trade off under varying dietary and farming conditions.

Methodological Contribution

This study's contribution can be summarized as follows:

- It embeds dietary patterns, agricultural practices, food waste reduction, renewable energy alternatives, and carbon sequestration within a single, coherent scenario framework, an integration no prior MFSS-based study has achieved.
- It reveals cross-sectoral trade-offs across the food-energy-ecology nexus that incrementally extended foodshed analyses cannot capture.
- It demonstrates this framework for Lower Franconia, Bavaria, and is designed for broader regional transferability.

Study Objectives

We pursue two sets of objectives:

Analytical and modeling objectives

1. Quantify the individual and combined effects of dietary patterns, food waste reduction, and farming systems on regional land footprints and self-sufficiency rates.
2. Model whether renewable energy sources (bioenergy crops, PV, wind) can satisfy regional energy needs on surplus land without compromising agricultural productivity.
3. Estimate GHGs and carbon sequestration potential across farming systems and scenarios.

Policy and interpretive objective

- Identify governance-relevant land allocation pathways that reveal opportunities, rather than prescribe outcomes, for communities, municipalities, and regional food system actors seeking to balance food provision, renewable energy deployment, and ecological restoration.

Materials and Methods

This section outlines our methodology and data collection process, covering the study area, indicators, and databases used. This is followed by the MFSS model and our adjustments, the novel approach to calculate energy potential and soil organic carbon (SOC) on available areas for renewable energy (ARE) and carbon sequestration (ASE), and, finally, the scenario development. A schematic overview is provided in Appendix Figure A1.

Study Area

The study develops a comprehensive framework to evaluate regional land-use opportunities, demonstrated through a model region embedded in local policy agendas. The model region is the governmental district of Lower Franconia (Nomenclature of Territorial Units for Statistics or NUTS 2), Bavaria, selected for its institutional support; primary data availability; and diverse landscape spanning intensively cultivated arable land, marginal areas, and a substantial share of organic farming. For transferability, several structural characteristics align with conditions found across many European and temperate regions: mixed conventional-organic farming, trade-dependent supply balancing, intermediate food self-sufficiency, and an active multi-level policy environment. However, Lower Franconia's relatively high agricultural productivity, specific crop portfolio, and dense institutional setting are context-specific. Readers applying this framework elsewhere should treat both absolute land footprint values and the relative ordering of scenario outcomes as region-specific, since local yield conditions, dietary baselines, and land availability may alter which pathways perform best. However, the methodological approach, combining foodshed analysis, energy land-use modeling, and emissions accounting, is designed to be broadly adaptable. Details on the study area are provided in the Appendix.

Databases

This study used various variables, indicators, and databases to carry out its calculations (see Appendix Table A3).

Metropolitan Foodshed and Self-sufficiency Scenario Model (MFSS)

The study applies an extended version of the MFSS framework originally developed by Zasada et al. (2019). This framework integrates regional food

consumption patterns with agricultural production parameters to evaluate foodshed extent and theoretical self-sufficiency across food groups, production systems, and food loss and waste levels. The framework relies on utilizable agricultural area (UAA), encompassing arable land, permanent grassland, and permanent crops; home gardens are excluded here since no data were available. For animal products, land footprints are calculated using conversion factors based on European studies accounting for feed requirements and processing losses. Dual-use animals serving both dairy and meat production purposes are not separately considered, which may marginally affect land, carbon, and emissions footprints. Regional yield data from 2018 to 2024 were used to estimate conventional yields of plant-based products, with organic yields assumed at 55% of conventional yields, following established values reported in the literature (Bayerische Landesanstalt für Landwirtschaft, n.d.),. Consumption data were sourced from official German statistics (Bundesministerium für Ernährung und Landwirtschaft, n.d.) and complementary reports, forming a food basket of 79 products.

Food categories were aggregated into representative commodity groups to maintain computational tractability and ensure data consistency, focusing on system-level self-sufficiency patterns while acknowledging that high-variance crops may introduce uncertainty (Joseph et al., 2019; Zasada et al., 2019). Key product categories include cereals (wheat, rye, oats), vegetables, fruits, legumes, fats, sugar, and sausage (composed of 20% beef, 55% pork, and 23% poultry (Treu et al., 2017)). Fish and seafood consumption were derived from the FAO FishStatJ database (FAO, n.d.). The analysis excluded items not producible in the region, such as coffee, tea, citrus fruits, and cacao, focusing exclusively on crops and livestock theoretically producible in Lower Franconia. This approach is consistent with that of Joseph et al. (2019). Our assumptions are consistent with regional scale foodshed modeling conventions and primarily affect absolute land footprint values more strongly than the relative ordering of scenarios. This pattern is confirmed by the sensitivity analysis (see Results and Appendix), which shows that ±20% variation in yields and consumption values shifts absolute estimates but leaves the comparative relationships between dietary patterns, farming systems, and energy alternatives unchanged.

Applying the MFSS: Calculation of Land Footprints and Associated Analyses

The following analyses were conducted to calculate land footprints:

Calculation of the specific land footprint, i.e., area demand (*A*) for each dietary style, organically and conventionally produced; *qi*: quantity of a specific food product, *i*, which is consumed per capita and per year in Germany; and *yi*: yield of crop *i* in kg/m² in the research area:

$$A = qi * yi \qquad (1)$$

A formal probabilistic uncertainty analysis was not conducted, reflecting the study's focus on establishing comparative scenario estimates rather than predictive quantification. However, a scenario-based sensitivity analysis was performed to assess the influence of key parameter variation on model outputs (see Appendix). Several parameters exhibited significant variability—organic yield assumptions, food waste rates, and consumption data, derived from regional or national averages—leading to uncertainty about land footprint and self-sufficiency outcomes. The sensitivity analysis confirmed that ±20% variation in yields and consumption values shifts absolute land demand estimates but does not alter the relative ordering of scenarios. This indicates that the main comparative conclusions are robust to explain plausible parameter variations. Shifts in the organic yield ratio or a decrease in food loss and waste would both substantially increase surplus land estimates. The broad scenario design, spanning dietary patterns and farming systems, partially brackets this variability by capturing a wide range of plausible land-use outcomes.

Calculation of the potential land footprint by taking food loss and waste along the value chain into consideration (*Aw*: area considering loss and waste, *w*: percentage of waste and/or loss):

$$Aw = A * w \qquad (2)$$

Calculation of the overall regional area demand (*Agg*), multiplying the per capita demand with the population of the research area (*pop.*: population in Lower Franconia):

$$Agg = A * pop. \text{ or}$$
$$Agg = Aw * pop. \quad (3)$$

Similarly to the model of Zasada et al. (2019), food self-sufficiency is interpreted as the relationship between the aggregate area demand (*Agg*) and the available agricultural area (*UAA* in hectare [ha]), expressed as self-sufficiency rate (*SSR*). Accordingly, an SSR of 100% would be realized if the complete area demand for food production could be covered within a region. Below that value, additional influx, i.e., imports of food from outside the region, are required. If the rate is larger, exports would be possible.

$$SSR = \frac{UAA}{Agg} * 100 \quad (4)$$

Calculation of the Energy Potential and Area for Renewable Energy (ARE)

In this study, land use for food production is prioritized over land use for (bio)energy production. The next step aims to estimate the potential area available for renewable energy production or other uses under different scenarios. This is done by using available or surplus ARE. ARE includes areas for carbon sequestration or natural vegetation (ASE). This means that the area required to meet 100% self-sufficiency of the Lower Franconian population is excluded. As described, we have calculated the aggregated area demand (i.e., area required to feed the population, Agg) and the food SSR, expressed as a percentage. As a premise, the SSR achieve at least 100%; the ARE would be the remaining area for each scenario. The model does not differentiate between cropland, grassland, and marginal land within ARE. However, the quality of the land has a direct impact on its suitability for the cultivation of energy or food crops.

$$ARE = UAA - Agg \quad (5)$$

Where *ARE* is area available for planting bioenergy crops or other uses (in hectares [ha]), *UAA* is the total utilizable agricultural area (ha), and *Agg* is the area required to feed the population (ha), according to the specific scenario.

We estimated the potential electricity generation of different energy crops from the database of bioenergy in Germany (Fachagentur Nachwachsende Rohstoffe, n.d.) and regional data (Bayerische Landesanstalt für Landwirtschaft, n.d.). The average amounts of energy that can be produced, either for biogas or thermal use, are presented in Appendix Table A4.

Primary Energy Consumption

According to the calculations in the working paper of Agora Energiewende (2024), primary energy consumption in Germany will decrease from 13,129 petajoules (PJ) to 6,458 PJ from 2018-2045, a reduction of 50%. This is due to a large reduction in energy generation from fossil sources and an increase in energy derived from renewable sources such as wind turbines and solar. These values were broken down to the primary energy consumption per capita in Germany. Subsequently, based on the population of Lower Franconia, different energy consumption values were calculated for our research area (Appendix Table A5). National per-capita energy consumption was used as a proxy for the region to provide a consistent benchmark, acknowledging that local industrial energy needs may differ from the German average. From these values, area needs were calculated based on the needs of Lower Franconia (Appendix Table A6). As open-space PV and wind energy play a crucial role, area demands for these were also calculated.

Beyond bioenergy crops and renewable energy installations, surplus areas present significant potential for alternative or complementary utilization, most notably carbon sequestration, natural vegetation restoration (ASE), and the provision of associated ecosystem services.

Estimation of Soil Organic Carbon (SOC) Sequestration

Crop cultivation influences SOC accumulation, humus content, and soil fertility, while also enabling soils to function as CO_2 sinks. Considering the car-

bon (C) sequestration rate and the assumption that all the area designated for carbon sequestration (ASE) is converted to natural vegetation (after meeting 100% of ARE), it is possible to estimate the potential C and CO_2 equivalent (CO_2e) that could be sequestered in the soils of temperate continental zones (e.g., our research area). Similarly to Fehrenbach and Bürck (2022) for areas in Germany, the potential carbon storage capacity on surplus land or land left aside is determined based on the concept of today's potential natural vegetation, i.e., forests. The corresponding average annual carbon storage rate is 2.9 metric tons C/ha and year. However, soil carbon sequestration potential is highly site-specific and nonlinear, with accumulation capacity depending on existing carbon stocks and soil type characteristics, among other factors (Georgiou et al., 2025). This study does not differentiate soil type variability or land-use categories.

Comparison of Emissions Regarding Different Land Uses

Land emissions vary depending on the agricultural practices applied. Aside from soil composition and tillage methods, one crucial factor is whether agricultural land is managed conventionally or organically (Bennetzen et al., 2016). We used the values from Hülsbergen et al. (2022), where organically managed land had total GHG emissions of 1.22 t CO_2e/ha and conventionally managed land 2.99 t of CO_2e /ha. The data from Hülsbergen et al. (2022) come from a pilot network comprised of 40 organic and 40 conventional market crop and dairy farms in four regions in Germany. There was no regional data available on carbon content or the carbon source-sink relationship. Thus, the total CO_2 storage capacity of Lower Franconia was calculated using the UAA and the carbon storage rate for Germany. Single product emissions were calculated by using values from Chiriacò et al. (2022). As a result, CO_2 credits (storage capacity) and emissions (climate impact) were contrasted.

Scenario Development

This study applies the MFSS model to simulate 24 distinct land-use scenarios based on the following factors:

- Differences in agricultural practices (organic vs. conventional),
- Different dietary styles (see below), and
- Impacts of food loss and waste, from production to household level.

Production System

Organic agriculture typically requires more land per unit of food produced due to lower yields. In our study, organic yields were set at 55% of conventional yields (Bayerische Landesanstalt für Landwirtschaft, n.d.). This is consistent with yield gap estimates reported in the broader literature, which state that organic yields are approximately 20-45% lower than conventional yields, depending on crop type, soil quality, and management intensity (Röös et al., 2018). This suggests that our assumption represents a plausible central estimate for the region.

Dietary Styles

This study distinguishes between four different dietary styles: omnivorous diet (baseline), flexitarian diet, vegetarian diet, and vegan diet. The dietary compositions applied in this study are based on the EAT-Lancet Planetary Health Diet and Willett et al. (2019) and have been adapted following Eberle and Mumm (2024). Descriptions and compositions can be found in the Appendix and Appendix Table A7.

Food Loss and Waste

For the development of the scenarios on food loss and waste, five levels along the food value chain were distinguished according to Zasada et al. (2019) (see Appendix). The estimated waste percentages for each commodity group in each step of the food value chain for Europe are from Gustavsson et al. (2011) (Appendix Table A8).

Table 1 provides an overview of the developed scenarios. Conventional scenarios are shown on the left and organic scenarios are listed on the right.

To strengthen the policy and community relevance of the scenario comparison, we interpreted results through a governance lens. Specifically, three implementation domains were used to assess scenario outcomes: 1) community-level food practices and demand-side interventions, such as die-

tary change or food waste reduction; 2) municipal planning and public decision-making, including land-use zoning, renewable energy siting, public procurement, and biodiversity-oriented land management; and 3) regional food system coordination, including implications for farming strategies, processing, supply chain organization, and stakeholder collaboration. This interpretive step does not constitute a separate social-impact model, but it allows the quantitative scenario outputs to be translated systematically into potential pathways.

Results

In this section, we first describe land footprints and food self-sufficiency rates before reporting land use for energy production, followed by emissions and SOC sequestration.

Land Footprint and Food Self-Sufficiency

Table 2 (in conjunction with Appendix Table A9) shows the following calculations for each scenario: potential land footprint in square meters (m^2), aggregated for the research area (Agg in hectare), and SSR. The table also indicates how many people (P) per ha could be fed. Additionally, the area for ARE and its relative share are shown. Area for carbon sequestration or natural vegetation (ASE) is included in ARE. Note that UAA remains stable. Furthermore, the table illustrates land footprints across different dietary scenarios. For example, the first row shows the results of the conventional baseline scenario, Ic. Its land footprint is 1,229 m^2 and its (across the research area) aggregated area is 173,978 ha, which equals 49.7% of the UAA. The self-sufficiency rate is 201%. In total, 7.7 people (P) can be fed by one hectare on this diet. The calculated ARE is 176,094 ha, which equals 50.3% of the UAA.

Overall, conventional scenarios show lower land footprints than organic ones. The baseline organic scenario shows the highest land footprint at 1,877 m^2, with significant potential for reduction across alternative diets. In contrast, the baseline conventional diet has a land footprint of 1,229 m^2. The transition to reduced food loss and waste along the value chain, in both "without losses" and

Table 1. Scenario Framework

Conventional Scenarios							Organic Scenarios						
Scenario	Baseline	Flexi	Veget	Vegan	w/o hh	with hh	Scenario	Baseline	Flexi	Veget	Vegan	w/o hh	with hh
I_c	X						I_o	X					
II_c	X				X		II_o	X				X	
III_c	X					X	III_o	X					X
IV_c		X					IV_o		X				
V_c		X			X		V_o		X			X	
VI_c		X				X	VI_o		X				X
VII_c			X				VII_o			X			
$VIII_c$			X		X		$VIII_o$			X		X	
IX_c			X			X	IX_o			X			X
X_c				X			X_o				X		
XI_c				X	X		XI_o				X	X	
XII_c				X		X	XII_o				X		X

w/o hh = without household-level waste
with hh = with household-level waste
Different combinations of dietary styles plus considered waste (without household-level waste (w/o hh) or with household-level waste (with hh)) have different scenario codes. For example, the Ic scenario is the baseline conventional scenario. Scenario IIIc is the conventional baseline scenario, which considers food loss and waste at all levels, i.e., including household level.

"with losses" scenarios, consistently lowers land footprints across all dietary patterns. Flexitarian organic diets result in moderate reductions, with land footprints of 1,465 m^2 without losses and 1,262 m^2 with losses compared to the baseline. Vegetarian organic diets achieve more substantial reductions, with land footprints of 956 m^2 without losses and 809 m^2 with losses. Vegan conventional diets demonstrate the lowest land footprint, particularly when food losses are minimized, with values of 476 m^2 without losses and 422 m^2 with waste and losses.

All scenarios reach at least 100% SSR. The baseline organic scenario has the lowest SSR at 139%. SSR increases as dietary changes are introduced, reaching 158% without losses and 191% with losses for the organic scenario. In the conventional scenario, these rates climb to 201% for baseline, 228% without losses, and 284% with losses. Flexitarian diets further raise SSR, registering 264% for the conventional and 179% for the organic scenario. Vegetarian diets show a sharp increase in SSR compared to the status quo, reaching 508% for the conventional scenario with losses and 391% for the organic scenario with losses. Vegan diets demonstrate the highest overall values, with SSR reaching 620% for the conventional scenario with losses and 491% for the organic scenario with losses.

Breaking down the land footprints (without waste and food losses) to individual products and product groups, respectively, the large share of animal-based products becomes clear (see Appendix Table A10). By comparing the share of plant- and animal-based products in diets with the share of plant- and animal-based products in land footprints, it becomes clear that one third of animal-based food in diets contributes to more than 70% of the land footprints. In scenarios where organic yields are used, the land footprints of animal-based products are higher than in conventional scenarios. This is attributable solely to differences in yield.

When comparing area used for specific products or product groups with their respective consumed amount, Lower Franconia is characterized by high production rates of sugar beets, canola, winter wheat, and winter barley. Appendix Tables A11 and A12 illustrate the self-sufficiency values of select regionally produced food products.

Land Use for Renewable Energy

As shown in all scenarios, there is surplus area available after 100% self-sufficiency. The amount of surplus area ranges from 28.2% in the organic baseline scenario to 97.6 % in the organic vegan scenario where food waste (including household-level) is considered (Table 2).

When comparing the production potential of different energy crops such as silage maize, Miscanthus, Silphia, permanent grassland, and winter wheat to meet the primary energy need, none of these crops can deliver 100% in our research area. Moreover, as Lower Franconia has areas that are very suitable for agricultural use, the share of energy crops is very low; for example, maize had a share of around 10% of the UAA in 2020 (Bayerisches Landesamt für Statistik, 2024).

Regarding the three scenarios of Agora Energiewende (2024), the areas needed for open-space PV and wind energy to meet the primary energy consumption were calculated (ARE). As those renewables only use a portion of the land, they have a higher energy output per land area (Böhm, 2024; Yin et al., 2024). Thus, when using either open-space PV or wind energy in the remaining areas, there is still a substantial surplus of areas for other uses, such as carbon sequestration or natural vegetation (equal to ASE). This holds true for all three years (2018, 2025, 2045).

Emissions and Soil Organic Carbon (SOC) Sequestration

Environmental impacts vary between organic and conventional management, with organic agriculture generally producing lower emissions by avoiding mineral nitrogen fertilizers, combining crop and livestock production, and applying regional nutrient recycling, though results differ by GHG, climate, soil conditions, and crop type (Gerke, 2025). Appendix Table A15 presents the carbon sequestration potential of surplus areas alongside food-related emissions across scenarios. The total carbon storage capacity of available utilized agricultural area (UAA) in Lower Franconia is 3.73 million t CO_2e (own calculation), with natural vegetation

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Table 2. Land Footprints, Self-Sufficiency Rates, and ARE for Conventional and Organic Scenarios

	Conventional						Organic					
	Scenario	Footprint (A/Aw) in m²	Agg in ha (share of UAA in %)	SSR in %	P/ha	ARE in ha (share in %)	Scenario	Footprint (A/Aw) in m²	Agg in ha (share of UAA in %)	SSR in %	P/ha	ARE in ha (share in %)
Baseline	Ic											
Baseline w/o hh	IIc											
Baseline with hh	IIIc											
Flexi	IVc											
Flexi w/o hh	Vc											
Flexi with hh	VIc											
Veget	VIIc											
Veget w/o hh	VIIIc											
Veget with hh	IXc											
Vegan	Xc											
Vegan w/o hh	XIc											
Vegan with hh	XIIc											

Notes: w/o hh = without household-level waste, with hh = with household-level waste, m² = square meters, Agg = aggregated area in ha, SSR = self-sufficiency rate, P/ha = people fed per hectare (ha), ARE = area for renewable energy, total UAA: 350,072 ha (remains stable)
Land footprints (A/Aw): red: >1,000 m², orange: <1,000 m² and >750 m², yellow: <750 m² and >500 m², green: <500 m²
Agg: red: >200,000 ha, orange: <200,000 ha and >100,000 ha, yellow: <100,000 ha and >75,000 ha, green: <75,000 ha
SSR: red: <300%, orange: <400% and >300%, yellow: <500% and >400%, green: >500%
P/ha: red: <10.0, orange: >10.0 and >15.0, yellow: >15.0 and <20.0, green: >20.0
Surplus area: red: <150,000 ha, orange: >150,000 ha and <200,000 ha, yellow: >200,000 ha and <250,000 ha, green: >250,000 ha

sequestering 10.64 t CO_2e/ha (Fehrenbach & Bürck, 2022). Emissions are highest in the conventional baseline scenario (-0.52 million t CO_2e) and lowest in the vegan scenario with food waste reduction (-0.17 million t CO_2e), the latter also yielding the greatest carbon sequestration potential on areas for renewable energy and carbon sequestration (ARE/ASE) at 3.12 million t CO_2e. Organic scenarios show similarly low emissions (e.g., -0.09 million t CO_2e in XIIo), but their higher land footprints reduce available ARE/ASE, and thus carbon sequestration potential (2.97 million t CO_2e in XIIo). Our data indicate that emissions vary significantly across dietary styles, with plant-based diets producing the lowest emissions per capita due to the lower resource intensity of plant-based foods. Meat-intensive diets, conversely, require more land and generate higher emissions. In all scenarios, the carbon-saving potential of agriculturally used land is higher than respective food-related emissions. Moreover, we see the highest sequestration rates in ARE/ASE.

In the next step, we considered the areas, emissions, and sequestration effects that would be released if food waste and losses could be spared or minimized. Emissions in Appendix Table A14 are characterized by a minus sign to indicate a negative impact. Our results confirm that preventing food losses could not only save agricultural land but also spare emissions and enable more carbon sequestration. The organic scenarios (in grey) have the largest potential impact on releasing land. Again, the carbon-saving potential of land not used for agriculture is higher than food-related emissions. Calculated emissions for single products or product groups can be found in Appendix Table A15.

We calculated that the total carbon or CO_2e storage capacity of the UAA in Lower Franconia is 3.73 million metric tons. The highest carbon sequestration potential is achieved in scenarios with the smallest land footprint (a vegan diet, considering food waste and losses across all stages of the value chain), resulting in the greatest surplus area and sequestration purposes (ARE/ASE).

The lowest carbon storage rates were observed in scenarios where land use is high, such as in the baseline (meat-based) and organic farming scenarios. Thus, scenarios with relevant natural vegetation preservation or organic farming practices show higher carbon storage capacities, providing climate benefits. In contrast, land-intensive energy or conventional plant production contribute to higher CO_2 emissions.

Upon combining different land-use options and considering emissions of renewables such as wind or open PV on one hand and carbon storage capacities on the other hand, we calculated a decrease in emissions originating from different diets and an increase in storage potential. The results for wind energy are summarized in Tables A16 and Table A17 in the Appendix, alongside a projected decrease in primary energy consumption from 2025-2045, according to Agora Energiewende (2024). This reduction is derived from a substantial reduction in energy production from fossil sources and an increase from renewable sources. Table A18 and Table A19 in the Appendix show the results for the use of PV energy. In the baseline scenario and the baseline scenario where household-level food waste and loss are not considered, emissions exceeded storage capacity in 2025.

Sensitivity Analysis

Sensitivity analyses, which examine how changes in data or assumptions affect results, are essential for evaluating the robustness of conclusions (Thabane et al., 2013). A sensitivity analysis assessing ±20% variation in yields, consumption values, and waste rates, confirmed that while absolute land footprint values shift within this range, the comparative relationships between scenarios remain stable. Among all parameters tested, meat and dairy consumption emerged as the most influential, followed by organic yield assumptions and food waste rates. In contrast, variations in minor food categories and cereal yields produced comparatively modest effects on land demand. The relative ordering of dietary patterns, farming systems, and energy alternatives is robust to parameter variation across all tested conditions. Details can be found in the Appendix (in conjunction with Appendix Table A18 and Figures A3 and A4).

Discussion

In this section we interpret our results in the context of existing literature, give a narrative synthesis

of our main findings, and formulate implications for community development and local government. Additionally, limitations and recommendations for further research are described.

Interpretation of Results in the Context of Existing Literature

The MFSS model estimates land required to meet regional food demand based on dietary composition and agricultural yields (Zasada et al., 2019). Our study extends this framework to Lower Franconia, Germany, analyzing 24 scenarios combining dietary styles, agricultural practices, and food waste levels, while assessing alternative land uses including energy generation, emissions, and carbon storage to demonstrate how competing land-use demands can be reconciled regionally.

Our results indicate that dietary shifts, improved soil management, and reduced food loss can substantially mitigate environmental impacts, with regional land simultaneously supporting diverse diets, renewable energy, biodiversity conservation, and exports. Carbon sequestration potential exceeded food-related emissions across all scenarios, though as soil carbon saturates over time, production-side emission reductions become increasingly important.

Our findings align with German and EU climate and sustainability strategies. EAT-Lancet-based diets and reduced animal product consumption support lower agricultural GHG emissions and improved resource efficiency, while differentiated land use and diverse crop rotations—as explicitly prioritized in the German Sustainability Strategy—contribute to soil health and biodiversity (Bundesumweltministerium, n.d.). These outcomes also correspond directly to the European Farm to Fork Strategy's objectives of sustainable food production, responsible consumption, and food waste reduction (European Commission, n.d.).

At the EU level, the Nature Restoration Law 2050 (Regulation (EU) 2024/1991) mandates the restoration of 20% of land and sea areas by 2030 and all degraded ecosystems by 2050. Our results indicate that, even with 20% of agricultural land allocated to restoration, food self-sufficiency, energy production, and ecological objectives remain achievable.

Baseline land footprints in our scenarios are comparable to previous research (Eberle & Fels, 2016; Treu et al., 2017; Zasada et al., 2019). Hallström et al. (2015) reported land demands of 1,400-2,100 m^2 per capita, similar to our findings. As in Treu et al. (2017), organic scenarios required more land for animal-based products than conventional systems, whereas reductions in meat consumption substantially decreased land demand (Hallström et al., 2015; Wirsenius et al., 2020). Differences in land footprints across studies reflect variations in food basket composition and inclusion criteria; for instance, coffee and cacao were excluded here because their primary production occurs outside the study region. Organic farming reduces synthetic input use and runoff (Sanders et al., 2025; Seufert & Ramankutty, 2017) but requires more land due to lower yields. In our study, land footprint differences between conventional and organic systems ranged from 26% (vegan diets) to 48% (flexitarian), consistent with Treu et al. (2017).

Regional characteristics strongly shape outcomes. In Lower Franconia, limited grassland constrains meat and dairy production, while high-quality winter wheat and sugar beets support exports. Consequently, self-sufficiency of commodities differs from calculated land footprints. Some of the consumed products, such as citrus fruits and coffee, cannot be produced locally, making full self-sufficiency unattainable. Crop diversity and dietary habits are further influenced by heterogeneous soil, climate, cultural, and socio-economic factors (Vicente-Vicente, Sanz-Sanz, et al., 2021). Environmentally, plant-based diets reduce emissions and land demand. Health-wise, EAT-Lancet-aligned diets support disease prevention and nutritional adequacy. Yet, if regional production cannot supply sufficient protein diversity, tensions may arise between environmental and health goals. Culturally, food habits and traditions influence dietary adoption. If proposed diets diverge too far from established practices, transitions may be slow, limiting real-world impact compared to modeled scenarios. Comparisons with the Bavarian Food Consumption Survey (Rohm et al., 2025) indicate differences in consumption patterns due to sample size and reporting biases in the survey. Assessment metrics utilized also influence outcomes; land use ex-

pressed per kilogram, kcal, and nutrient intake yields all produce different results (Poore & Nemecek, 2018).

Our results confirm that food waste is a major driver of land demand. Losses of roots, fruits, cereals, pulses, and particularly cereals at the consumption stage substantially increase land footprints (Gustavsson et al., 2011). Reducing waste can lower per capita land use and support sustainability targets (Augustin et al., 2020; Schneider et al., 2022). Demographic trends, including declining rural populations and growing urban centers (Eurostat, n.d.), will further affect land-use dynamics. Despite sustainable intensification, global food self-sufficiency is projected to decline as demand outpaces production (Beltran-Peña et al., 2020).

Most food-related emissions originate from animal-based products. Differences between organic and conventional diets are less pronounced, as lower yields in organic systems offset reductions in emissions per hectare (Sanders et al., 2025). Nonetheless, organic farming can reduce environmental runoff by avoiding synthetic fertilizers and pesticides (Seufert & Ramankutty, 2017), though land-saving potential depends on closing the yield gap (Foley et al., 2005). Carbon storage potential was estimated using recent German data (Fehrenbach & Bürck, 2022), though sequestration is nonlinear and depends on soil type and existing carbon levels (Georgiou et al., 2025).

Narrative Synthesis of the Main Findings

Across all scenarios, three overarching patterns were identified. First, dietary shifts and food waste reduction are the strongest levers for lowering land demand within the regional food system. Second, organic production reduces some management-related environmental burdens but increases land demand because of lower yields, thereby intensifying trade-offs when land is scarce. Third, if food provision is secured first, wind and PV systems offer substantially higher energy output per unit of land than dedicated bioenergy crops, leaving greater scope for ecological restoration and carbon sequestration.

Taken together, the results show that the most promising pathways are not single-sector solutions but combinations of demand-side change, land-efficient renewable energy deployment, and context-sensitive agricultural strategies. Addressing these interactions requires an interdisciplinary perspective that integrates insights from agriculture, energy systems, and land-use governance. In this sense, the scenarios identify not one optimal blueprint, but a set of feasible regional pathways that differ in their implications for land competition, climate performance, and governance complexity.

Community Development and Local Governance Implications

The contribution of this study to regional food systems development lies less in predicting social outcomes than in clarifying which land-use pathways expand or constrain the options available to local actors. A key limitation is that the model does not incorporate socioeconomic, political, or institutional feasibility, factors that will shape which pathways are pursued in practice. Scenario results should therefore be read as evidence-based opportunity spaces. Within those boundaries, the findings have relevant implications for community development and municipal governance, as illustrated in Table 3.

Limitations

Our analysis is limited by the exclusion of trade flows, which may overlook dependencies on imported or exported food and associated environmental impacts. This limitation primarily affects absolute self-sufficiency estimates rather than the relative ranking of scenarios, as trade exclusion applies uniformly across all scenarios. Other limitations include the simplification of livestock systems, which may not capture variations in production intensity and could affect absolute land footprint values, particularly in omnivorous and flexitarian scenarios. However, the directional differences between dietary patterns remain intact. Moreover, the scenarios are static snapshots rather than dynamic projections and therefore do not capture transition pathways, such as the adoption of dietary changes, infrastructure development, or phased renewable energy deployment over time. This limitation affects the interpretation of all scenarios equally and does not alter relative comparisons.

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Table 3. Translation of Key Scenario Findings into Community and Governance Implications

Key scenario finding	What it means analytically	Community-level implications	Municipal and/or regional policy implications	Implications for regional food system stakeholders
Dietary shifts toward flexitarian, vegetarian, or vegan patterns reduce land demand relative to baseline scenarios.	Reduced dietary land footprints directly expand surplus land available for energy and restoration uses across all production systems.	Food literacy and school meal reform may support a shift away from the specific food groups—particularly beef and dairy—that the scenarios identify as driving the largest land footprint differences between omnivorous and plant-based dietary patterns.	Scenario-specific land savings suggest that food strategies and climate plans could reference these findings. Procurement policies may offer one avenue for operationalizing demand shifts already quantified in the model.	Findings indicate that product portfolios and processing capacity may need to reflect a gradual shift away from high-land-intensity animal products that the scenarios consistently identify as the dominant driver of regional land demand differences across all production systems.
Food waste reduction lowers required production area independently of dietary or farming system changes.	Land savings from waste reduction are additive to dietary shifts, suggesting combined measures yield the greatest surplus land across all 24 scenarios.	Awareness and redistribution initiatives may usefully prioritize the waste fractions—particularly at household and retail level—that the model identifies as carrying the highest land footprint per unit across dietary scenarios.	Model-derived land savings from waste reduction, which the scenarios show are additive to dietary shifts, suggest that municipal waste prevention plans could reference these findings to inform investment in redistribution and procurement standards.	Findings indicate that coordinating storage, logistics, and surplus redistribution may reduce the land demand embedded in wasted regional production, an effect the scenarios show holds independently of dietary pattern or farming system.
Organic scenarios require more land under the 55% yield assumption, offsetting some ecological gains.	Ecological benefits of organic systems come with quantifiable land competition trade-offs that vary by dietary scenario, most pronounced in omnivorous patterns and reduced in plant-based diets (vegetarian or vegan).	Scenario evidence suggests that community dialogue on organic transitions may benefit from engaging with the specific modelled land trade-offs, which the scenarios show are most manageable when combined with dietary shifts toward lower land-intensity patterns.	Modelled land constraints suggest that organic expansion targets could be considered alongside demand-side measures. The scenarios indicate that flexitarian or vegetarian diets substantially reduce the net land penalty associated with organic production.	Findings suggest that crop choice, contracting, and processing capacity could be considered in relation to land availability scenarios, particularly given that organic land requirements vary considerably depending on the dietary context in which they are assessed.

Wind and PV satisfy regional energy demand on a fraction of the land required by bioenergy crops.	The model indicates bioenergy cannot meet regional energy needs within available surplus land. Wind and PV can, while preserving land for food and restoration.	Model results may inform participatory planning for wind and PV siting by indicating which surplus land areas, greatest under plant-based and low-waste scenarios, appear least needed for food or carbon uses.	Findings suggest that land-efficient renewables may warrant prioritization across all scenarios; agrivoltaic options on lower-quality soils may merit further examination, particularly where surplus land is limited under conventional omnivorous conditions.	Scenario evidence suggests that farm-level diversification into wind and PV leasing or cooperatives may be viable across all dietary and farming system combinations, as energy goals do not require trade-offs in land available for food production in any scenario tested.
Surplus land supports carbon sequestration and ecological restoration with quantifiable climate co-benefits.	Land set-aside for natural vegetation carries modelled carbon sequestration potentials that the scenarios show are greatest under plant-based diets (vegetarian, vegan) and low food waste conditions.	Where surplus land is identified, particularly under vegetarian and vegan scenarios, scenario evidence may support community deliberation on prioritizing ecological restoration and multifunctional landscape uses alongside food and energy goals.	Findings suggest that restoration could be considered as a quantified climate measure within regional land strategies. The scenarios indicate that its feasibility increases substantially under plant-based dietary patterns and waste reduction measures.	Modelled sequestration values, which vary across dietary and farming system scenarios, may support farms and regional organizations in developing stewardship and ecosystem-service arrangements grounded in scenario-specific regional evidence.
Exclusion of trade flows means self-sufficiency rates reflect theoretical production capacity, not realized supply autonomy.	Model results represent an upper bound on self-sufficiency. Actual regional food provision depends on trade infrastructure and market linkages not captured in any of the 24 scenarios.	Findings suggest that community messaging may benefit from distinguishing between the theoretical production potential identified in the scenarios and actual food security, avoiding overstatement of self-sufficiency, particularly under high-surplus plant-based scenarios.	Results indicate that foodshed findings may be most informative when combined with food flow and infrastructure analyses before informing supply chain or resilience policy, as high modelled self-sufficiency rates do not necessarily translate into realized regional autonomy.	Findings suggest that processing, wholesale, and market dependencies could usefully be mapped alongside model outputs when designing regional sourcing or resilience strategies, as these structural factors shape whether modelled surplus land translates into actual food system change.

This study does not provide a formal probabilistic uncertainty analysis for yields, SOC sequestration, or energy production, as its primary aim is a comparative, scenario-based assessment of land-use trade-offs rather than predictive quantification. While these parameters are uncertain and spatially heterogeneous, the sensitivity analysis confirmed that ±20% variation in key parameters shifts absolute land demand estimates but leaves the relative ordering of dietary patterns, farming systems, and energy alternatives unchanged. A further limitation of this study is that the model provides comparative scenario insights but does not account for sociopolitical, economic, or cultural constraints, meaning the results indicate potential trade-offs and opportunities rather than prescriptive policy guidance. Furthermore, the framework remains a capacity-based foodshed analysis and does not model actual trade flows or market exchange. The reported self-sufficiency rates should therefore be interpreted as theoretical production capacity under the specified assumptions, not as realized regional autonomy. This distinction is particularly important in regions with strong import or export linkages, where production and consumption are not tightly aligned. In such contexts, land released under alternative dietary or waste scenarios may not translate directly into local food system transformation, because producer decisions, processing infrastructure, contracts, and broader market conditions will shape how these opportunities are used.

More generally, the results should be interpreted comparatively rather than as precise forecasts. Several assumptions, notably organic yield gaps, emission factors, conversion efficiencies, and the allocation of surplus land to renewable energy or ecological restoration, affect the absolute values but do not alter the directional conclusions of the scenario analysis. However, the main purpose of the scenario analysis is to compare directional differences between pathways under a common set of assumptions.

The strongest conclusions of the study therefore concern the relative ordering of options, such as the consistently high land efficiency of wind and PV systems compared to dedicated bioenergy crops, and the substantial land-saving effects of dietary change and food waste reduction, findings that remain robust across the range of parameter variation tested.

Recommendations

Our results highlight the need for integrated regional governance linking agriculture, climate, and energy strategies (Jónsdóttir & Gísladóttir, 2023). Three findings are particularly policy-relevant. First, dietary guidelines should align with climate objectives (Ritchie et al., 2018), emphasizing reduced meat consumption and promotion of legumes, given their influence on regional land demand (Balázs et al., 2021; van Selm et al., 2022). Second, wind and PV systems offer higher land-use efficiency than bioenergy crops, enabling energy transitions without displacing food production (Böhm, 2024; Nitsch et al., 2012). Third, integrated land and resource planning, combining waste reduction, circular land-use practices, and nature-based solutions can simultaneously strengthen ecological sustainability (Searchinger et al., 2022; Seddon, 2022).

Regional food systems can enhance resilience but must balance local sovereignty with global food security (Beyer et al., 2022; Kaufmann et al., 2022). Ikerd (2025) proposes food-based communities committed to food sovereignty as a model for local empowerment. By applying our framework to a model region, we demonstrate how local policies and conditions could shape feasible pathways for these dimensions, with the framework's value lying in making complex land-use trade-offs understandable to the communities, institutions, and food system actors who may need to negotiate them. For communities, the model illustrates how dietary transitions, particularly toward plant-based or flexitarian diets, may reduce land demand and environmental pressures while maintaining cultural acceptability. Importantly, these transitions are not purely technical choices but involve food culture, social norms, and equity considerations that communities themselves must navigate. Scenario results may guide public awareness campaigns, institutional food policies, and CSA. For municipalities, the framework may support integrated land-use and energy planning. Comparing scenarios for food production and renewable energy may help munici-

palities consider land allocations that minimize competition, protect high-value soils, and align with climate and biodiversity goals. Results could inform zoning policies, dual land-use strategies such as agrivoltaics, and public procurement decisions, enhancing policy coherence across departments. Yet their translation into policy requires engagement with local planners, farmers, and residents whose priorities and constraints shape what is institutionally and politically feasible. For food system stakeholders, including producers, processors, retailers, and civil society organizations, the framework demonstrates how production strategies may interact with regional demand and ecological constraints. Organic and conventional farming scenarios may identify where sustainable practices are viable without increasing land pressure. Such insights on crop-livestock balance and regional self-sufficiency may support value-chain coordination, investment planning, and resilience strategies, particularly for smaller producers and cooperatives whose decisions collectively shape regional land use but who rarely have access to integrated scenario evidence of this kind.

While the framework is grounded in modeling, its application in practice is inherently a social and political process. The pathways pursued, and by whom, are dependent on community agencies, local priorities, and the inclusiveness of governance processes. Translating scenario evidence into food system change requires participatory processes that engage diverse stakeholders, including smallholder farmers as well as community food initiatives, whose perspectives may not be reflected in aggregate land-use metrics. Equity considerations are equally important, as dietary transitions and land reallocation may have uneven distributional consequences across income groups, land tenure arrangements, and farming scales. Future applications would therefore benefit from integrating scenario development into participatory planning processes that are directly responsive to the needs and priorities of the communities under study.

Looking ahead, future reforms of the European CAP may further shape regional food availability through more targeted production incentives. In the context of sustainability transitions and the growing demand for plant-based foods, policy instruments could potentially be used to encourage the production of plant-based protein crops, such as soybeans or other legumes. Expanding domestic production of such crops could contribute to diversifying regional food systems, strengthening local value chains, and reducing reliance on imported protein sources.

Our framework may function as a multi-level governance tool, translating complex interactions into accessible, scenario-based evidence for policymakers and food system stakeholders. By revealing unintended consequences of single-sector decisions, the framework may support more coherent consideration of land-use strategies across communities, municipalities, and regional food systems. Overall, this approach offers a structured evidence base that may help bridge scientific analysis and deliberation around diets, production, and energy planning, identifying potential pathways and offering opportunity spaces for actors seeking to align food, energy, and ecological objectives.

Future research should expand this approach to other regions, refine land-type differentiation, incorporate realistic organic farming scenarios, and evaluate diverse dietary patterns. Additional dimensions, including water, nutrient cycles (N, P), and biodiversity footprints must be assessed to fully align with policy frameworks. Addressing these aspects may support comprehensive strategies for ecologically sustainable regional food systems.

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Appendix. Supplementary Figures and Data

Overview of European Foodshed Analyses

Zasada et al. (2019) developed the Metropolitan Foodshed and Self-sufficiency Scenario (MFSS) model to estimate the agricultural area (as a radius) required to feed the populations of four European cities: London (GB), Berlin (DE), Milan (IT), and Rotterdam (NL). The original model focuses on domestic and imported products but does not consider food flow networks between spatial entities, categorizing it as a capacity study (Schreiber et al., 2021). Excluding these flows can bias regional self-sufficiency assessments, particularly in areas with high import or export activity, by disconnecting local production from actual consumption patterns. In import-dependent regions, self-sufficiency may be underestimated, while in export-oriented regions, it may be overestimated, potentially misinforming policy decisions. Table A1 gives an overview of further local-scale studies.

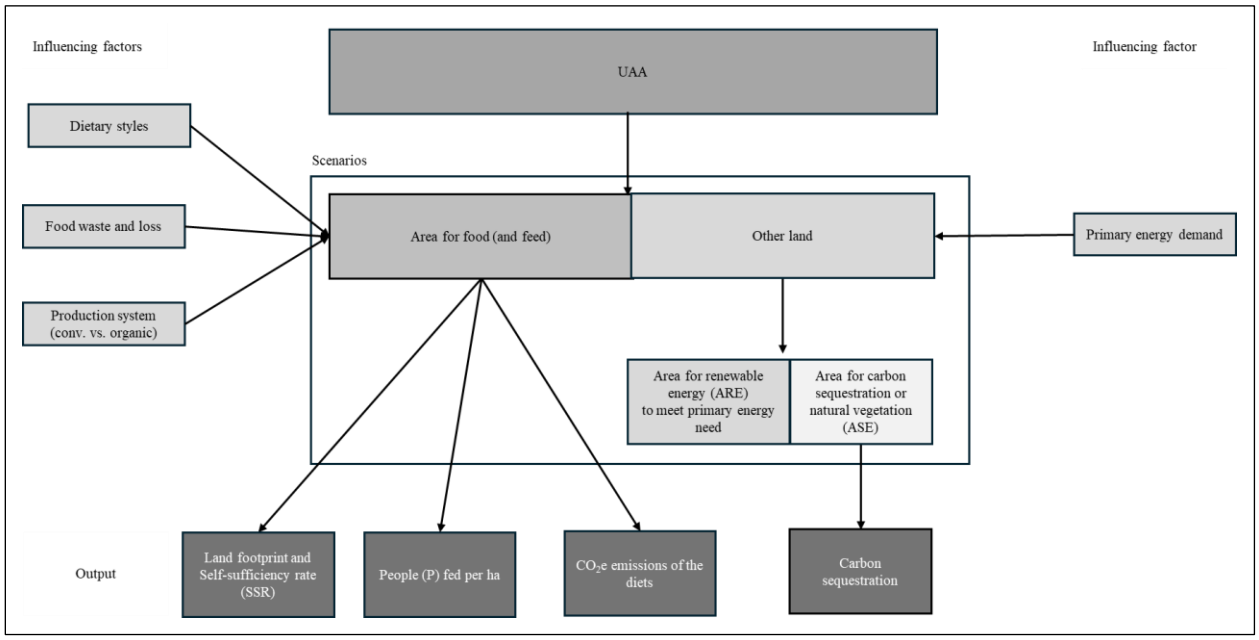
Table A1. Thematic Grouping of Relevant Local-Scale Literature

Theme	Author(s), year	Focus or objective	Geographic scope	Method or model
Foodshed Analyses	Joseph (2019)	Calculated local food self-sufficiency potential under different diets and production system combinations	Hamburg (DE)	Foodshed analysis
	Sylla (2022)	Analyzed capacity of local food systems to supply vegetable-based diets	Nine European cities: Wrocław (PL), Ostend (BE), Berlin (DE), Avignon (FR), Copenhagen (DK), Bari (IT), Brașov (RO), Athens (EL), Barcelona (ES)	MFSS model
	Vicente-Vicente, Doernberg, et al. (2021)	Assessed self-sufficiency considering organic production, diet, food waste, and population growth	Vienna (AT), Bristol (UK)	MFSS model
	Vicente-Vicente, Sanz-Sanz, et al. (2021)	Combining MFSS with data on cropping patterns, soil and topography to develop a "foodshed archipelago"	Avignon (FR)	MFSS model
	Vicente-Vicente & Piorr (2023)	Conducted foodshed analysis to support local food strategy	Munich and Bavaria (DE)	MFSS model
Bioenergy & Food Systems	Tavakoli-Hashjini et al. (2020)	Evaluated potential bioenergy production from Miscanthus while ensuring food self-sufficiency and ecosystem services	Brandenburg (DE)	MFSS model and backcasting
Flow Analyses	Moschitz & Frick (2021)	Investigated city food flows	Leutkirch (DE), Waldkirch (DE)	Flow analysis

Source: Own compilation. This list does not claim to be exhaustive.

Schematic View of the Research Approach

Figure A1. Schematic View of the Research Approach

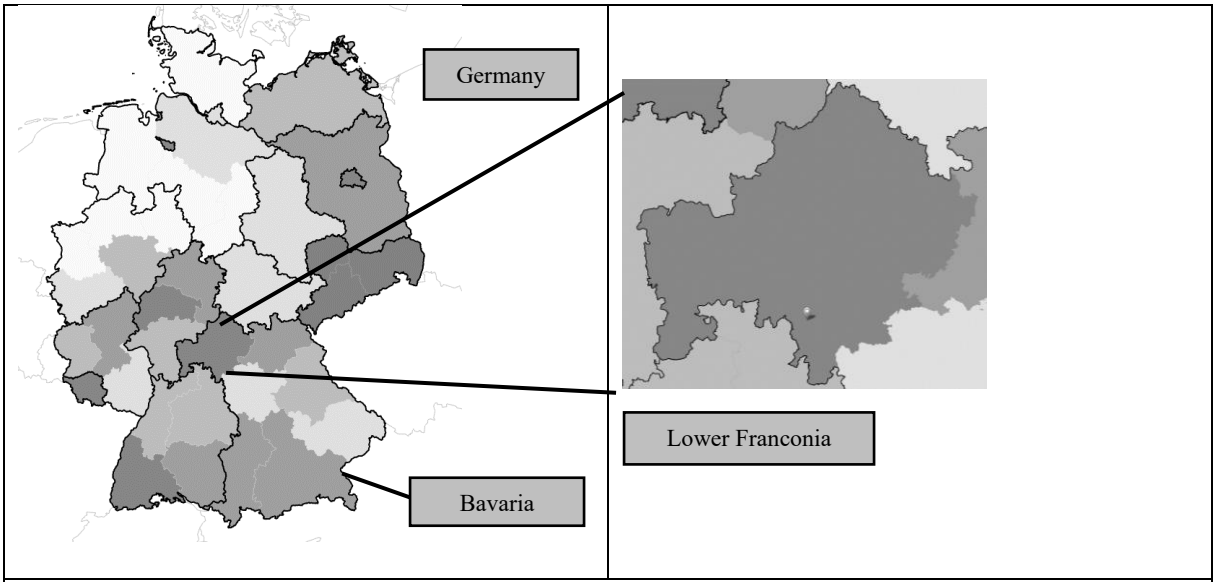


Source: Own compilation. UAA: utilized agricultural area, SSR: self-sufficiency rate, ARE: area for renewable energies, ASE: area for carbon sequestration or natural vegetation

District of Lower Franconia

The district of Lower Franconia is located in northeastern Bavaria (Figure A2), has a population of 1.34 million people, and covers an area of 3293.8 square miles (8,531 km²) (Bayerisches Landesamt für Statistik, 2024).

Figure A2. Map of Germany, Bavaria, and the Research Area, Lower Franconia



Note: The different shades have no significance for this study. Source: Statistische Ämter des Bundes und der Länder (n.d.)

Lower Franconia ranks fifth place in terms of area among the Bavarian districts. The altitude varies between 335.6 and 1,978.4 feet (102 and 603 meters) above sea level. Agricultural land accounts for 41% of Lower Franconia's area, of which 78.5% is arable land, 19.4% permanent grassland, and 2% permanent cropland (mainly viticulture). For a comparison of Lower Franconia to Bavaria and Germany, see Table A2. Lower Franconia has no peatland, its permanent grassland is managed extensively, and the region has a low livestock density (Bayerisches Staatsministerium für Ernährung, Landwirtschaft, Forsten und Tourismus, 2025).

Table A2. Comparisons between Lower Franconia, Bavaria, and Germany

Indicator	Lower Franconia	Bavaria	Germany
Average size of agricultural businesses in hectares (ha)	44.0	36.6	63.2
Share of arable land	78.5%	66%	70.3%
Share of grassland	19.4%	33%	28.5%
Share of permanent cropland	2.0%	0.4%	1.2%
Share of organic agriculture	13.9%	11.6%	11.4%
Average yield of conventional winter wheat (organic = 55%) in tons per ha	6.21 (3.42)	7.17 (3.97)	7.08 (3.89)
Livestock units/ha utilized agricultural area	0.33	0.84	0.72

Sources: Bayerisches Landesamt für Statistik, 2024; Bayerische Landesanstalt für Landwirtschaft, n.d. ; Bayerisches Staatsministerium für Ernährung, Landwirtschaft, Forsten und Tourismus, 2025; Bundesministerium für Landwirtschaft, Ernährung und Heimat, n.d.

In Lower Franconia, the annual precipitation is 29.4 inches (747 millimeters (mm)). The average German precipitation is 31.1 inches (789 mm) (Deutscher Wetterdienst, n.d.). Thus, most crops are rain-fed. However, due to climate change, farmers face longer growing seasons, increasing drought, more frequent heavy rainfall events, and changes in nutrient availability (e.g., Verma et al., 2025).

Soils in the research area contain sandstone, loess, and limestone. Thus, parts of Lower Franconia are very suitable for agricultural use. The most prominent crops in Lower Franconia are winter wheat, canola, soybeans, and sugar beets, which are often produced in food-quality and are crucial export goods. Consequently, the share of energy crops is relatively low (Bayerisches Landesamt für Statistik, 2024). High export orientation does not affect assumptions of local self-sufficiency in the MFSS model. The proportion of organic agriculture ranges from 5% in favorable areas to 25% in less favorable areas (Bayerische Landesanstalt für Landwirtschaft, n.d.; Bundesministerium für Landwirtschaft, Ernährung und Heimat, n.d.).

Relevant Indicators and Literature Sources

Most parameters were compiled using a single reference year, which served as the main basis for the data set. When values for that exact year were not available in the literature or statistical sources, we used data from years that were closest to the reference year and considered representative for the same production context. No formal temporal standardization of the data sets was performed.

Table A3. Relevant Indicators and Literature Sources

Indicator or value	Spatial scale	Reference year	Source(s)
Structural and resource use indicators			
Data on agricultural structure	Lower Franconia, Bavaria, and Germany	2024 2025	Bayerisches Landesamt für Statistik, 2024 Bayerische Landesanstalt für Landwirtschaft, n.d. Bundesministerium für Ernährung und Landwirtschaft, n.d. Bayerisches Staatsministerium für Ernährung, Landwirtschaft, Forsten und Tourismus, 2025
Share of land use for energy crops	Bavaria	2024	Bayerisches Landesamt für Statistik, 2024 Fachagentur Nachwachsende Rohstoffe, n.d.
Land-use footprints per kg of food product of select food items	World	2018	Poore & Nemecek, 2018
Production and yield indicators			
UAA	Lower Franconia, Bavaria, Germany	2025	Bundesministerium für Ernährung und Landwirtschaft, n.d. Bayerisches Staatsministerium für Ernährung, Landwirtschaft, Forsten und Tourismus, 2025
Yield data	Lower Franconia and Bavaria	2024	Bayerisches Landesamt für Statistik, 2024 Bayerische Landesanstalt für Landwirtschaft, n.d.
Emission, carbon, and greenhouse gas (GHG) indicators			
Annual carbon storage rate (2.9 t C/ha*a)	Germany	2022	Fehrenbach & Bürck, 2022
Emissions of conventional and organic fields	Germany	2022	Hülsbergen et al., 2022
GHG emissions of major food products	Germany	2018 2025	Poore & Nemecek, 2018 Umweltbundesamt, n.d.
Emissions for single products or product groups	Europe	2022	Chiriacò et al., 2022

Emissions from PV and wind energy generation	Germany, Europe	2020	Kaltschmitt et al., 2020
Energy production and efficiency indicators			
Average and range of energy that can be produced from energy crops	Germany	2024	Fachagentur Nachwachsende Rohstoffe, n.d. Kaltschmitt & Stampfer, 2024
Primary energy consumption	Germany	2024	Agora Energiewende, 2024
Consumption and food intake indicators			
Consumption data	Germany	2024	Eberle & Mumm, 2024 Joseph et al., 2019 Vicente-Vicente & Piorr, 2023
Fish consumption data	Germany	2024	FAO FishStatJ database FAO, n.d.
National food balance and food intake	Germany	2024	FAO, 2025
Food loss and waste indicators			
Food loss at different stages of the value chain	Europe	2011	Gustavsson et al., 2011
Demographics			
Population	Lower Franconia	2023	Bayerisches Landesamt für Statistik, 2023

Average and Range of Energy that can be Produced from Energy Crops

Table A4. Average and Range of Energy that can be Produced from Energy Crops

Crop	Energy production (for biogas or thermal use) in MWh/ha	Yield in t DM/ha (unless indicated otherwise)
Maize WPS (32% DM)	47	25
Miscanthus WPS (80% DM)	85	18 (10-30)
Silphium WPS (25% DM)	35.1	10-20
Perennial ryegrass WPS (20% DM)	37.9	10-19
Permanent grassland	7.4-14.0	6-14 t DM/a (intensive) 2.3-15.5 t DM/a (extensive)
Green rye WPS (35% DM)	12.6	20 t FM/ha
Winter rye WPS (86% DM)	17	8-12
Triticale WPS (86% DM)	18.6	8-12
Winter wheat WPS (86% DM)	25	8-12

WPS = whole-plant silage, MWh = megawatt-hour, ha = hectare, DM = dry matter, FM = fresh matter, a = year. Source: Kaltschmitt & Stampfer, 2024

Primary Energy Consumption

Table A5. Primary Energy Consumption in Germany and Lower Franconia

Year	Primary energy consumption in Germany in PJ	Primary energy consumption in Lower Franconia in GWh
2018	13,129	57,653
2025	9,897	43,460
2045	6,458	28,359

PJ = petajoule; 1 PJ equals 278 GWh (gigawatt-hour)
Source: Agora Energiewende, 2024

Table A6. Energy Production and Area Needed to Meet Primary Energy Consumption Needs (2018, 2025, and 2045)

	Energy production in MWh/ha	Area needed to meet primary energy consumption needs in 2018 in ha	Area needed to meet primary energy consumption needs in 2025 in ha (reduction in %)	Area needed to meet primary energy consumption needs in 2045 in ha (reduction in %)
Open-space PV	1,000	57,653	43,460 (-25%)	28,359 (-50%)
Wind energy	20,000	2,883	2,173 (-25%)	1,418 (-50%)

MWh/ha = megawatt-hour per hectare
Source: Agora Energiewende, 2024; Kaltschmitt & Stampfer, 2024

Dietary Compositions

An **omnivorous diet** (baseline) includes both animal- and plant-based foods—meat, fish, dairy, eggs, grains, legumes, fruits, and vegetables. Diets high in processed meats and saturated fats are linked to increased risks of cardiovascular disease, obesity, and certain cancers (Godfray et al., 2018; Pan et al., 2012).

A **flexitarian diet** is mainly plant-based with occasional animal products, often chosen for health, ethical, or environmental reasons. It is associated with lower risks of chronic diseases, including heart disease, type 2 diabetes, and some cancers (Derbyshire, 2017).

A **vegetarian diet** excludes meat, poultry, and fish, relying on plant proteins and often including dairy and eggs. It is linked to reduced body weight, blood pressure, and inflammation (Key et al., 2006). In 2024, 7% of Germans and 36% of Indians identified as vegetarians (Statista, 2025a).

A **vegan diet** excludes all animal-derived products and is entirely plant-based. It is associated with reduced disease risks (Craig, 2009; Key et al., 2006). In 2024, 4% of Germans and 10% of Indians followed a vegan diet (Statista, 2025b).

The dietary compositions applied in this study are based on the EAT-Lancet Planetary Health Diet and Willett et al. (2019) and have been adapted following Eberle and Mumm (2024) (Table A5). "Baseline" refers to the average balanced German nutrition with products that can be produced locally.

Table A7. Summary of the Different Dietary Patterns (in descending order for the baseline column)

Product or product group	Baseline kg/(capita*a)	Flexitarian kg/(capita*a)	Vegetarian kg/(capita*a)	Vegan kg/(capita*a)
Cereals	92.60	87.90	84.68	84.68
Vegetables	77.66	117.06	126.47	219.00
Fruits	77.18	79.46	85.85	109.50
Milk	44.74	36.38	39.30	0.00
Sugar	26.69	10.95	10.95	10.95
Potatoes	26.44	19.50	21.07	33.91
Yogurt	25.96	28.74	31.05	0.00
Sausage	21.85	6.08	0.00	0.00
Cheese	21.04	2.91	3.15	0.00
Fats and oils	15.68	16.83	18.30	18.30
Eggs	9.94	4.59	4.75	0.00
Pork	8.62	5.11	0.00	0.00
Poultry	6.33	8.10	0.00	0.00
Beef	5.78	5.11	2.58	0.00
Butter	5.16	0.36	0.39	0.00
Fish	4.98	7.62	0.00	0.00
Legumes	2.97	57.58	72.40	81.09
Nuts	2.73	8.69	9.13	9.13
Sum	489.35	507.49	512.13	569.13

Source: Data calculated from Eberle & Mumm, 2024.

Food Loss and Waste

The following five levels of food loss and waste along the food value chain were distinguished according to Zasada et al. (2019):

- Reduced production output due to mechanical damage and rejects during harvest or disease and death of animals in agricultural production;
- Rejects and damage during postharvest treatment, postharvest handling, storage, and transportation;
- Inefficiencies in processing and packaging (e.g., due to technical failure and over- or underproduction); and
- Losses and waste in the wholesale, retail, and distribution systems (depreciation or spoilage and within the food service industry).
- Waste by the end consumer at home or eating out.

Table A8. Estimated or Assumed Waste Percentages for Each Commodity Group in Each Step of the Food Value Chain for Europe, Including Russia

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket Retail	Consumption
Cereals	2%	4%	10%	2%	25%
Fish and seafood	9.4%	0.5%	6%	9%	11%
Fruits and vegetables	20%	5%	2%	10%	19%
Meat	3.1%	0.7%	5%	4%	11%
Milk	3.5%	0.5%	1.2%	0.5%	7%
Oilseeds and pulses	10%	1%	5%	1%	4%
Roots and tubers	20%	9%	15%	7%	17%

Source: Gustavsson et al., 2011

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Table A9. Land Footprint and Food Self-Sufficiency

	Conventional						Organic					
	Scenario	Footprint (A/Aw) in m²	Agg in ha (share of UAA in %)	SSR in %	P/ha	ARE in ha (share in %)	Scenario	Footprint (A/Aw) in m²	Agg in ha (share of UAA in %)	SSR in %	P/ha	ARE in ha (share in %)
Baseline	Ic	1,229	173,978 (49.7)	201	7.7	176,094 (50.3)	Io	1,877	251,316 (71.8)	139	5.3	98,756 (28.2)
Baseline w/o hh	IIc	1,147	153,552 (43.9)	228	8.7	196,520 (56.1)	IIo	1,652	221,173 (63.2)	158	6.1	128,899 (36.8)
Baseline with hh	IIIc	922	123,369 (35.2)	284	10.8	226,703 (64.8)	IIIo	1,368	183,053 (52.3)	191	7.3	167,019 (47.7)
Flexi	IVc	993	132,846 (37.9)	264	10.1	217,226 (62.1)	IVo	1,465	196,103 (56.0)	179	6.8	153,969 (44.0)
Flexi w/o hh	Vc	852	114,013 (32.6)	307	11.7	236,059 (67.4)	Vo	1,262	168,945 (48.3)	207	7.9	181,127 (51.7)
Flexi with hh	VIc	729	97,536 (27.9)	359	13.7	252,536 (72.1)	VIo	1,085	145,227 (41.5)	241	9.2	204,845 (58.5)
Veget	VIIc	732	98,005 (28.0)	357	13.7	252,067 (72.0)	VIIo	965	127,975 (36.6)	274	10.5	222,097 (63.4)
Veget w/o hh	VIIIc	619	82,893 (23.7)	422	16.1	267,179 (76.3)	VIIIo	809	108,268 (30.9)	323	12.4	241,804 (69.1)
Veget with hh	IXc	515	68,973 (19.7)	508	19.4	281,099 (80.3)	IXo	670	89,615 (25.6)	391	14.9	260,457 (74.4)
Vegan	Xc	618	82,660 (23.6)	424	16.2	267,412 (76.4)	Xo	781	104,475 (29.8)	335	12.8	245,597 (70.2)
Vegan w/o hh	XIc	476	63,751 (18.2)	549	21.0	286,321 (81.8)	XIo	603	80,669 (23.0)	434	16.6	269,403 (77.0)
Vegan with hh	XIIc	422	56,462 (16.1)	620	23.7	293,610 (83.9)	XIIo	533	71,280 (20.4)	491	18.8	278,792 (97.6)

w/o hh = without household-level waste, with hh = with household-level waste, m² = square meters, Agg = aggregated area in ha, SSR = self-sufficiency rate, P/ha = people fed per ha, ARE = area for renewable energy, total UAA: 350,072 ha (remains stable)
Land footprints (A/Aw): red: >1,000 m², orange: <1,000 m² and >750 m², yellow: <750 m² and >500 m², green: <500 m²
Agg: red: > 200,000 ha, orange: < 200,000 ha and > 100,000 ha, yellow: < 100,000 ha and >75,000 ha, green: < 75,000 ha
SSR: red: <300%, orange: <400% and >300%, yellow: <500% and >400%, green: >500%
P/ha: red: <10.0, orange: >10.0 and >15.0, yellow: >15.0 and <20.0, green: >20.0
Surplus area: red: <150,000 ha, orange: >150,000 ha and <200,000 ha, yellow: >200,000 ha and <250,000 ha, green: >250,000 ha

Share of Products or Product Groups on Selected Land Footprints

Animal-based products include meat and dairy products, which contribute at least one-third to the land footprints. Due to lower feed conversion efficiency, beef products contribute to a high land footprint: 37% in the conventional baseline scenario and 45% in the organic baseline scenario. The results highlight the role of beef and dairy in driving high land footprints (Table A10).

Table A10. Share of Products or Product Groups on Selected Land Footprints in %

Scenario		Meat and sausage	Dairy	Cereals	Fats	Fruits	Potatoes	Vegetables	Eggs	Fish	Legumes	Nuts	Sugar
Baseline conv.	**Ic**	37	30	12	7	5	1	2	3	<1	0	1	2
Baseline org.	**Io**	45	23	11	6	4	1	2	5	<1	0	1	2
Flexi conv.	**IVc**	32	15	15	10	6	1	4	2	<1	12	3	1
Flexi org.	**IVo**	39	14	14	8	5	1	3	3	<1	9	3	1
Veget conv.	**VIIc**	22	22	20	15	9	1	5	3	N/A	20	4	1
Veget org.	**VIIo**	23	23	21	14	9	1	6	5	N/A	17	5	1
Vegan conv.	**Xc**	N/A	N/A	23	17	14	2	11	N/A	N/A	26	5	2
Vegan org.	**Xo**	N/A	N/A.	25	17	14	2	12	N/A	N/A	23	6	2

Conv. = conventional, org. = organic, N/A = not applicable

Self-Sufficiency Values of Select Food Products or Product Groups

Tables A11 and A12 illustrate the self-sufficiency values of select (i.e., regionally produced) food products or product groups in conventional and organic scenarios, respectively.

Table A11. Food Product or Product Group Self-Sufficiency Values in % across Dietary Scenarios (Conventional)

Scenario		Cereals	Fats and oils	Potatoes	Vegeta-bles	Legumes	Fruits	Beef	Pork	Eggs
Baseline	**Ic**	1,159	590	118	100	510	14	80	171	24
Flexi	**IVc**	1,221	550	160	66	26	13	91	288	51
Veget	**VIIc**	1,268	506	148	61	21	12	0	0	50
Vegan	**Xc**	1,268	506	92	35	19	10	0	0	0

Table A12. Food Product or Product Group Self-Sufficiency Values in % across Dietary Scenarios (Organic)

Scenario		Cereals	Fats and oils	Potatoes	Vegeta-bles	Legumes	Fruits	Beef	Pork	Eggs
Baseline	Io	67	16	28	22	187	2	N/A	N/A	N/A
Flexi	IVo	71	15	38	15	10	2	N/A	N/A	N/A
Veget	VIIo	73	14	35	14	8	2	N/A	N/A	N/A
Vegan	Xo	73	14	22	8	7	2	N/A	N/A	N/A

N/A = no data available

The tables break down self-sufficiency values by food category across four dietary scenarios: baseline, flexitarian (Flexi), vegetarian (Veget), and vegan. Food categories include cereals, oilseeds/fats, potatoes, vegetables, legumes, fruits, beef, pork, and eggs. Dairy is excluded, as its production is very limited in Lower Franconia. The results show that cereals dominate the self-sufficiency values in all scenarios, with 1,159% in the baseline, 1,221% in the flexitarian, and 1,268% in the vegetarian and vegan diets. Values from oilseeds and fats remain consistent across all scenarios. Beef has an influence on the self-sufficiency values in the baseline and flexitarian diets, with values of 510% and 506%, respectively, but its value is eliminated in vegetarian and vegan scenarios. Pork and eggs contribute modestly to the baseline and flexitarian diets, while their self-sufficiency values are negligible or absent in vegetarian and vegan diets. Legumes, vegetables, fruits, and potatoes have lower self-sufficiency values than cereals and meats, though their contributions increase slightly in vegetarian and vegan diets.

Emissions and Soil Organic Carbon (SOC) Sequestration

Table A13. Emissions vs. Storage Capacities

	Conventional					Organic			
	Scenario	**Carbon sequestration** potential in million t CO_2e of **diets**	**Emissions** of the **diets** in million t CO_2e	Carbon sequestration potential in million t CO_2e of **ARE/ASE areas**		Scenario	**Carbon sequestration** potential in million t CO_2e of **diets**	**Emissions** of the **diets** in million t CO_2e	Carbon sequestration potential in million t CO_2e of **ARE/ASE areas**
Baseline	Ic	1.85	-0.52	1.87		Io	2.67	-0.31	1.05
Baseline w/o hh	IIc	1.63	-0.46	2.9		IIo	23.5	-0.27	1.37
Baseline with hh	IIIc	1.31	-0.37	2.41		IIIo	1.95	-0.22	1.78
Flexi	IVc	1.41	-0.40	2.31		IVo	2.09	-0.24	1.64
Flexi w/o hh	Vc	1.21	-0.34	2.51		Vo	1.80	-0.21	1.93
Flexi with hh	VIc	1.04	-0.29	2.69		VIo	1.55	-0.18	2.18
Veget	VIIc	1.04	-0.29	2.68		VIIo	1.36	-0.16	2.36
Veget w/o hh	VIIIc	0.88	-0.25	2.84		VIIIo	1.15	-0.13	2.57
Veget with hh	IXc	0.73	-0.21	2.99		IXo	0.95	-0.11	2.77
Vegan	Xc	0.88	-0.25	2.85		Xo	1.11	-0.13	2.61
Vegan w/o hh	XIc	0.68	-0.19	3.05		XIo	0.86	-0.10	2.87
Vegan with hh	XIIc	0.60	-0.17	3.12		XIIo	0.76	-0.09	2.97

t = metric tons. Sequestration potential of the available area: 3.73 million metric tons.

Table A14. Emissions vs. Carbon Storage Potential on Additional "Free" Agricultural Land Due to Food Loss and Waste

	Scenario	Additional freed-up area in ha	Total emissions in million t CO_2e	Total carbon sequestration potential in million t CO_2e	Δ (sequestration - emissions)
Baseline	Org./Conv.	77,338	-0.23*	0.82	0.59
	Conv. to losses w/o hh	20,425	-0.06	0.22	0.16
	Conv. to losses with hh	50,608	-0.15	0.54	0.39
	Org. to losses w/o hh	30,143	-0.04	0.32	0.28
	Org. to losses with hh	68,263	-0.08	0.73	0.64
Flexi	Org./Conv.	63,257	-0.19*	0.67	0.48
	Conv. to losses w/o hh	18,833	-0.06	0.20	0.14
	Conv. to losses with hh	35,310	-0.11	0.38	0.27
	Org. to losses w/o hh	27,158	-0.03	0.29	0.26
	Org. to losses with hh	50,876	-0.06	0.54	0.48
Veget	Org./Conv.	29,970	-0.09*	0.32	0.23
	Conv. to losses w/o hh	15,112	-0.05	0.16	0.12
	Conv. to losses with hh	29,032	-0.09	0.31	0.22
	Org. to losses w/o hh	19,707	-0.02	0.21	0.19
	Org. to losses with hh	38,360	-0.05	0.41	0.36
Vegan	Org./Conv.	21,815	-0.07*	0.23	0.17
	Conv. to losses w/o hh	18,909	-0.06	0.20	0.14
	Conv. to losses with hh	26,198	-0.08	0.28	0.20
	Org. to losses w/o hh	23,806	-0.03	0.25	0.22
	Org. to losses with hh	33,196	-0.04	0.35	0.31

*: calculated using 2.99 tons CO_2e per ha, w/o hh = without household-level waste, with hh = with household-level waste

Emissions for single products or product groups were calculated as described. When compared at an aggregated level, all dietary patterns show comparable emissions when calculating either with organic or conventional yields (Table A15). Broken down to single food products or product groups, we can confirm that emissions for meat production are among the highest. High values for cereals derive from the large amount of cereals consumed (e.g., bread and pasta). Note that cereals for feed were not considered here.

Table A15. Emissions of Products or Product Groups in CO_2e kg/(cap*a) – Conventional and Organic Scenarios

Conventional										
Scenario		Cereals	Vegeta-bles	Fruits	Milk	Legumes	Nuts	Beef	Pork	Poultry
Baseline	Ic	109	17	9	40	1	3	75	20	7
Flexi	IVc	104	26	10	33	13	8	66	12	9
Veget	VIIc	100	28	10	35	17	9	0	0	0
Vegan	Xc	100	48	13	0	19	9	0	0	0
Organic										
Baseline	Io	144	14	7	36	1	3	64	34	6
Flexi	IVo	136	21	7	30	12	8	57	20	7
Veget	VIIo	131	23	8	32	14	9	0	0	0
Vegan	Xo	131	39	10	0	16	9	0	0	0

Emissions vs. Storage Capacities - Wind Energy and PV Energy, 2025 and 2045

Table A16. Emissions vs. Storage Capacity - Wind Energy 2025

		Conventional					Organic		
Scenario		Emissions of wind turbines in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestra-tion potential in million t CO_2e for the respective scenario		Emissions of wind turbines in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestra-tion potential in million t CO_2e for the respective scenario
Baseline	**Ic**	-0.017	-0.52	1.85	**Io**	-0.017	-0.31	1.03
Baseline w/o hh	**IIc**		-0.46	2.07	**IIo**		-0.27	1.35
Baseline with hh	**IIIc**		-0.37	2.39	**IIIo**		-0.22	1.75
Flexi	**IVc**	-0.017	-0.40	2.29	**IVo**	-0.017	-0.24	1.62
Flexi w/o hh	**Vc**		-0.34	2.49	**Vo**		-0.21	1.90
Flexi with hh	**VIc**		-0.29	2.66	**VIo**		-0.18	2.16
Veget	**VIIc**	-0.017	-0.29	2.66	**VIIo**	-0.017	-0.16	2.34
Veget w/o hh	**VIIIc**		-0.25	2.82	**VIIIo**		-0.13	2.55
Veget with hh	**IXc**		-0.21	2.97	**IXo**		-0.11	2.75
Vegan	**Xc**	-0.017	-0.25	2.82	**Xo**	-0.017	-0.13	2.59
Vegan w/o hh	**XIc**		-0.19	3.02	**XIo**		-0.10	2.84
Vegan with hh	**XIIc**		-0.17	3.10	**XIIo**		-0.09	2.94

Calculated area needed for wind energy: 2,173 ha.

Table A17. Emissions vs. Storage Capacity - Wind Energy 2045

		Conventional				Organic		
Scenario		Emissions of wind turbines in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario		Emissions of wind turbines in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario
Baseline	**Ic**	-0.011	-0.52	1.86	**Io**	-0.011	-0.31	1.04
Baseline w/o hh	**IIc**		-0.46	2.08	**IIo**		-0.27	1.36
Baseline with hh	**IIIc**		-0.37	2.40	**IIIo**		-0.22	1.76
Flexi	**IVc**	-0.011	-0.40	2.30	**IVo**	-0.011	-0.24	1.62
Flexi w/o hh	**Vc**		-0.34	2.50	**Vo**		-0.21	1.91
Flexi with hh	**VIc**		-0.29	2.67	**VIo**		-0.18	2.17
Veget	**VIIc**	-0.011	-0.29	2.67	**VIIo**	-0.011	-0.16	2.35
Veget w/o hh	**VIIIc**		-0.25	2.83	**VIIIo**		-0.13	2.56
Veget with hh	**IXc**		-0.21	2.98	**IXo**		-0.11	2.76
Vegan	**Xc**	-0.011	-0.25	2.83	**Xo**	-0.011	-0.13	2.60
Vegan w/o hh	**XIc**		-0.19	3.03	**XIo**		-0.10	2.85
Vegan with hh	**XIIc**		-0.17	3.11	**XIIo**		-0.09	2.95

Calculated area needed for wind energy: 1,418 ha.

Table A18. Emissions vs. Storage Capacity - PV Energy 2025

		Conventional				Organic		
Scenario		Emissions of PV in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario		Emissions of PV in million t CO_2e	Emissions of diets in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario
Baseline	**Ic**	-1.26	-0.52	1.41	**Io**	-1.26	-0.31	0.59
Baseline w/o hh	**IIc**		-0.46	1.63	**IIo**		-0.27	0.91
Baseline with hh	**IIIc**		-0.37	1.95	**IIIo**		-0.22	1.32
Flexi	**IVc**	-1.26	-0.40	1.85	**IVo**	-1.26	-0.24	1.18
Flexi w/o hh	**Vc**		-0.34	2.05	**Vo**		-0.21	1.47
Flexi with hh	**VIc**		-0.29	2.23	**VIo**		-0.18	1.72
Veget	**VIIc**	-1.26	-0.29	2.22	**VIIo**	-1.26	-0.16	1.90
Veget w/o hh	**VIIIc**		-0.25	2.38	**VIIIo**		-0.13	2.11
Veget with hh	**IXc**		-0.21	2.53	**IXo**		-0.11	2.31
Vegan	**Xc**	-1.26	-0.25	2.38	**Xo**	-1.26	-0.13	2.15
Vegan w/o hh	**XIc**		-0.19	2.58	**XIo**		-0.10	2.40
Vegan with hh	**XIIc**		-0.17	2.66	**XIIo**		-0.09	2.50

Calculated area needed for open PV: 43,460 ha.

Table A19. Emissions vs. Storage Capacities - PV Energy 2045

		Conventional				Organic		
Scenario		Emissions of PV in million t CO_2e	Emissions in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario		Emissions of PV in million t CO_2e	Emissions in million t CO_2e	Carbon sequestration potential in million t CO_2e for the respective scenario
Baseline	Ic	-0.82	-0.52	1.57	Io	-0.82	-0.31	0.75
Baseline w/o hh	IIc		-0.46	1.79	IIo		-0.27	1.07
Baseline with hh	IIIc		-0.37	2.11	IIIo		-0.22	1.48
Flexi	IVc	-0.82	-0.40	2.01	IVo	-0.82	-0.24	1.34
Flexi w/o hh	Vc		-0.34	2.21	Vo		-0.21	1.63
Flexi with hh	VIc		-0.29	2.39	VIo		-0.18	1.88
Veget	VIIc	-0.82	-0.29	2.38	VIIo	-0.82	-0.16	2.06
Veget w/o hh	VIIIc		-0.25	2.54	VIIIo		-0.13	2.27
Veget with hh	IXc		-0.21	2.69	IXo		-0.11	2.47
Vegan	Xc	-0.82	-0.25	2.54	Xo	-0.82	-0.13	2.31
Vegan w/o hh	XIc		-0.19	2.75	XIo		-0.10	2.57
Vegan with hh	XIIc		-0.17	2.82	XIIo		-0.09	2.67

Calculated area needed for open PV: 28,359 ha.

Sensitivity Analysis

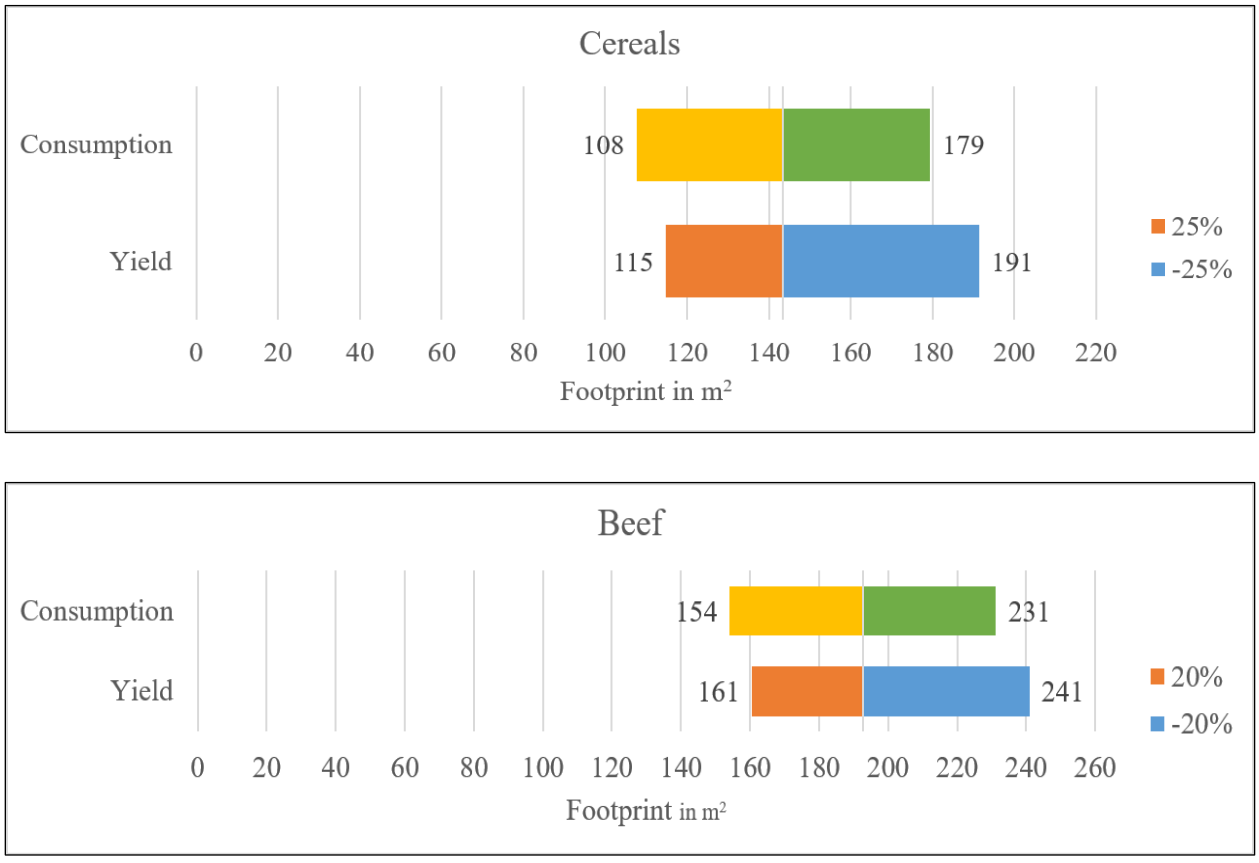
This study conducted two sensitivity analyses. The first was a breakdown of agricultural land use for each food product or product group. Some products and product groups were assigned to arable land (e.g., cereals, vegetables), some to permanent cropland (e.g., nuts), and some to permanent grassland plus arable land (e.g., meat, sausage, and dairy). The latter product groups were assigned 60% to grassland and 40% to arable land. The results reveal that there is no difference in the share of different land-use types within agriculture when conventional or organic production is considered (Table A20). This is because yield gaps are similar for most products.

Table A20. Share of Assigned Land in %

		Conventional			Organic		
	Scenarios	Arable land	Permanent grassland	Permanent cropland	Arable land	Permanent grassland	Permanent cropland
Lower Franconia	-	79.0	19.0	2.0	79.0	19.0	2.0
Baseline	Ic, Io	59.0	36.0	5.0	62.0	33.0	5.0
Flexi	IVc, IVo	68.0	23.0	9.0	69.0	22.0	8.0
Veget	VIIc, VIIo	73.0	13.0	14.0	73.0	14.0	13.0
Vegan	Xc, Xo	81.0	0.0	19.0	81.0	0.0	19.0

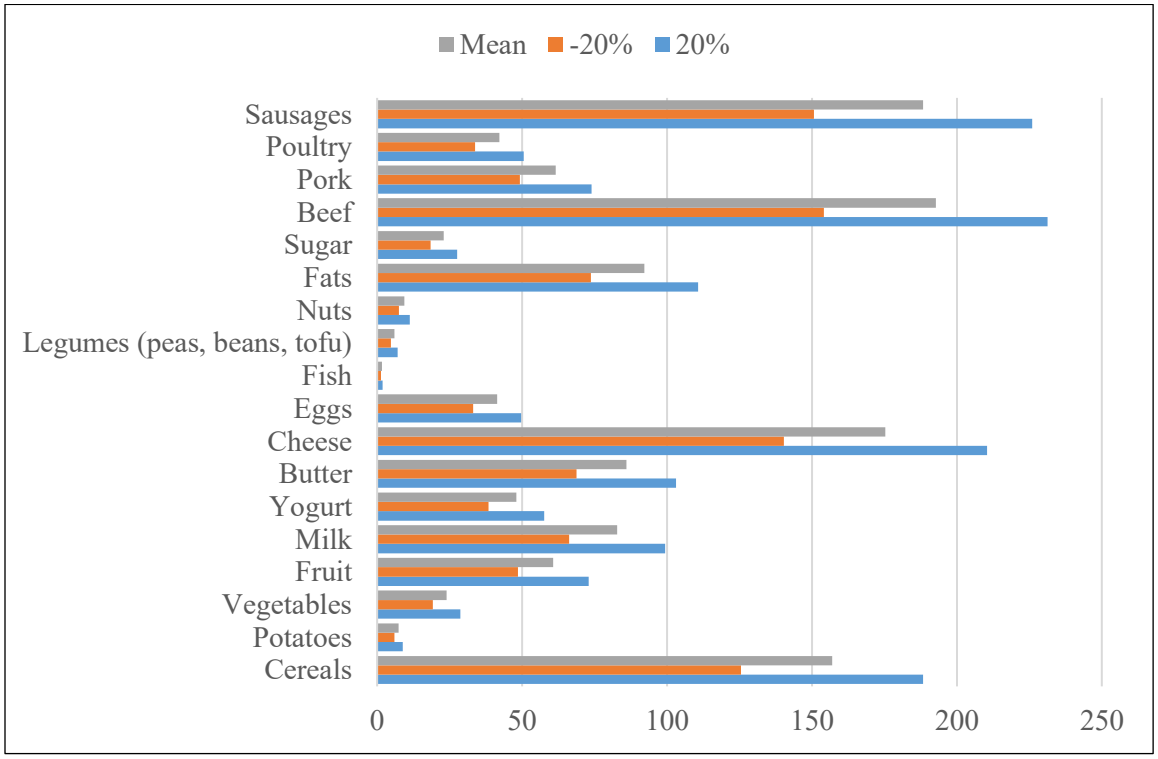
Second, the effects of ±20% changes in yield and consumption of food products and product groups on land footprint were analyzed to identify the most influential factors. Results confirmed that both the amount of food consumed and crop-specific yields are significant contributors to land footprint estimates. Under this range of variation, absolute values of land demand and related indicators, including self-sufficiency rates and surplus land availability, shift meaningfully. This underscores the importance of regional production conditions and sustainable dietary patterns as primary drivers of land-use outcomes. However, the overall comparative relationships between scenarios remain stable across this parameter range (not shown). The relative ordering of dietary patterns, farming systems, and energy alternatives is not altered by ±20% variation in yields, consumption, or waste rates, indicating that the main conclusions of the study are robust to plausible uncertainty in these parameters. Among individual product groups, meat and dairy consumption exert by far the greatest influence on land footprints, consistent with the scenario results reported in the main text (Fig. A3 and A4). Other product groups contribute more modestly to overall land demand variation. This pattern holds across both conventional and organic production systems, reinforcing the finding that dietary composition, particularly the share of animal products, is the dominant determinant of regional land footprints.

Figure A3. Results of the Sensitivity Analysis for ±20% Variation in Yields and Consumption for Single Products



The figure below shows ±20% variation in yields for all product categories in the baseline scenario.

Figure A4. ±20% Variation in Yields for All Products and Product Categories



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Connecting local food system actors for climate-friendly public catering in Germany: Lessons learned from a transformative and transdisciplinary research project

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Abstract

Climate-friendly nutrition is a pivotal subject for the future. The Climate-friendly Cafeterias (CliCa) project was initiated as a one-year transformative and transdisciplinary initiative to support the Karlsruhe (Germany) Climate Protection Concept 2030. Linked to this, the transformation goal of CliCa was to implement climate-friendly and sustainable measures (referred to as 'levers') in local cafeterias. These measures included increasing the share of organic, regional, seasonal, vegetarian, and vegan food, along with reducing food waste. The research goal (research question) was to identify the barriers for implementing levers. This was accompanied by the educational goal aimed to raise awareness among cafeteria staff and guests. The article presents the transdisciplinary design, addresses the research question, and evaluates the transformational goal by presenting outcomes (changes within the project duration) and impacts (changes after the project duration). Within the

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See disclosures and other information on nex page.

CliCa project, a heterogeneous network consisting of up to 40 actors was established, with a core group of 11 institutions engaging in regular participation. Two open questionnaires (N = 10 and N = 9) were conducted during the project's duration, and eight follow-up interviews were conducted two years after the project's conclusion. The data analysis revealed 10 key barriers to implementation and several measurable changes related to the identified levers. The most frequently cited barrier was 'Guest acceptance,' followed by 'Missing/unclear framework conditions,' 'Lack of money,' and 'Higher price.' The majority of barriers were mentioned in relation to the lever 'Increasing the use of organically produced food.' The findings of this study indicate that individual levers and barriers are interrelated and should be addressed in combination. With respect to the transformation goal, we conclude that establishing a stakeholder network with a focus on peer-to-peer counseling is particularly effective when participants encounter similar challenges and operate under comparable systemic conditions, such as infrastructure, acceptance by cafeteria guests, and economic frameworks.

Disclosure Statement
No potential conflict of interest was reported by the authors.

Ethics Approval
A privacy policy is available and has been signed by all participants. No prospective studies on humans. No Clinical trials. No Clinical Case reports. No Clinical Case reports. No Human embryos and human stem cells. No children, adolescents, and vulnerable or incapacitated study participants were included. No on indigenous communities.

AI Statement
DeepL Write was used as a tool to help translate the manuscript into academic English during the revision process.

Contributions of Authors
A.F. led the project CliCa, wrote the first draft of the manuscript, led the writing and review process, finalized the manuscript and communicated it to the journal. A.F, P.L., S.MS. and E.W. co-performed the project CliCa and the data analysis. F.B., P.L., S.MS. contributed to the first draft and the review process. S.MS. co-acquired and co-led the KARLA project and CliCa.

Keywords
climate-friendly nutrition, foodservice, public catering, institutional food, sustainable food systems, transdisciplinary, transformative research

Introduction

The notion of environmentally sustainable nutrition, and sustainable nutrition more broadly, is pertinent to the future. The food system, including cultivation to production, processing, transportation, and refrigeration, accounts for around 25% of all greenhouse gas emissions (Poore & Nemecek, 2018). In recent years, the public catering sector—encompassing all food consumed in public spaces such as schools, kindergartens, hospitals, and workplace and university cafeterias—has attracted the attention of policymakers and scientists who are seeking to address the climate and environmental challenges facing our food. The out-of-home catering sector is a major contributor to climate change, especially with regard to its carbon foodprint and food waste (Speck et al., 2022), and is considered to be a catalyst for transforming food production due to the substantial number of meals served to the public on a daily basis. According to the German Ministry for the Environment (BMU, 2018), 28% of the emissions caused by food preparation in Germany originate from large and public kitchens. As stated by the Federal Association of the German Food Industry (BVE, 2020), public catering[1] was responsible for 12.4 billion meals in 2019. In the context of out-of-home catering, Speck et al. (2021) identify a pivotal negotiating point for the food transition as significant impacts can be achieved by implementing changes in public catering, particularly in the domain of food procurement, given the substantial volume involved. Beyond the realm of sustainability, public catering institutions assume a central role in promoting healthful dietary practices. According to the EAT-Lancet Commission, food production is the most significant driver of global environmental change, and unhealthy diets are considered an even greater threat to human health and longevity than the combined effects of unsafe sex, alcohol, drugs, and

[1] The authors decided to use the term 'public catering,' since most of the literature they drew on was European. In the U.S., however, the terms 'institutional food' and 'foodservice' are more commonly used.

tobacco (Swinburn et al., 2019). The resolution of these two issues can be achieved by promoting sustainable and healthy nutrition through public catering. The report *Policies for More Sustainable Food* (Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection [WBAE], 2020) identifies four key objectives for sustainable nutrition: a healthy diet corresponding with minimum social standards along the value chain prioritizing animal welfare, and aligning with Germany's sustainability goals (SDGs). The challenge is twofold: to reduce greenhouse gas emissions from food production, and to implement measures that will enable the achievement of the four key objectives. The key question is how to bring about a fundamental transformation of the food sector.

Need for Transdisciplinary and Transformative Research

To surmount this challenge and answer this key question, it is imperative to address both global and local levels. Transformative and transdisciplinary research projects can generate robust social knowledge (Lang et al., 2012), which Gibbons (1999) defines as knowledge arising from society and therefore more likely to be accepted. Transdisciplinary research involves nonscientific actors in the research process, who participate substantially in the research endeavor (Bergmann, 2010). Transdisciplinary research focuses on the collaborative development of action and solution strategies pertinent to practical applications that address real-world problems (Bergmann, 2010). Transformative research endeavors are driven by the overarching objective of effecting a great transformation (German Advisory Council on Global Change [WBGU], 2011) and providing robust knowledge at the local level. This knowledge is often applied in real-world laboratories that operate at the interface between society and science (Parodi & Seebacher, 2024).

As part of the Karlsruhe Real-World Laboratory for Sustainable Climate Protection (KARLA), the Climate-friendly Cafeterias[2] (CliCa) project was designed in a transformative, transdisciplinary manner. The project supports the Karlsruhe Climate Protection Concept (City of Karlsruhe, n.d.), measure E1.8: 'Climate-friendly Lunchtime Catering in Municipal Canteens and Cafeterias' by generating robust social knowledge and promoting transformation at the local level in cafeterias. To address the complexity of real-world-problems, the project team[3] defined the research goals, transformation goals, and educational goals (Beecroft & Parodi, 2016; Schäpke et al., 2017; Singer-Brodowski et al., 2018) simultaneously. The transformation goal was to implement climate-friendly and sustainable measures (so-called 'levers') in local cafeterias by increasing the proportion of organic, regional, seasonal, vegetarian, and vegan food items on menus or screens and reducing food waste in public catering facilities in Karlsruhe. The research goal was to identify barriers to implementing climate-friendly measures. The research question addressed in this article accordingly is: What are the barriers to implementing climate-friendly measures in cafeterias? The educational goal was to raise awareness among local actors, cafeteria staff, and cafeteria guests about these issues. In this article, we[3] outline the transdisciplinary process, in which a network of actors was formed through various networking events, such as cafeteria visits, and FutureBowls (networking events combining theoretical input, networking, and exchange). Next, we present the results of the identified barriers and the projects' impact on transforming local cafeterias.

Applied Methods and Data Analysis

To answer the research question and evaluate the transformation goal, the project team applied the methods listed in Table 1. The educational goal was not further operationalized or measured but is addressed in the Discussion section.

[2] The term 'cafeteria' is used in this study because it is being published in a U.S.-based journal. However, in British English and European contexts, the term 'canteen' (German: Kantine) is more common. Canteens/cafeterias are catering facilities in companies, government agencies, schools, or hospitals that primarily serve hot meals to employees, students, or patients in hospitals.
[3] In this article, 'project team' refers to the persons who worked directly in CliCa and carried out the transdisciplinary process. 'We' refers to the article's authors. This distinction was made because the authors and the project team members overlap in terms of personnel but are not identical.

Design of the Transdisciplinary Process

Jahn et al. (2012) developed a popular model of an ideal typical transdisciplinary research process. However, the authors used the framework of Ferretti et al. (2016) to present the transdisciplinary process, breaking it down into five consecutive steps: Step 1: Joint identification of research needs; Step 2: Agreement on expectations and goals; Step 3: Establishment of continuous communication during the research process; Step 4: Formulation and transfer of research results; and Step 5: Reflection on the research process. Steps 1 to 3 are pre-

Table 1. Overview of Methods Applied, Objectives, Respondents, and Analysis

Method applied	Objective	Respondents		More information and analysis
Open-ended Questionnaire 1	(1) Get inquiries regarding barriers to implement climate-friendly measures (i.e., the "levers") (2) Obtain inquiries regarding the actors' prior experience with individual levers	Approximately 20 actors participated in the FutureBowls on a regular basis, representing a total of 17 institutions, with 11 institutions being represented in more than two FutureBowls Multiple actors were designated to represent a single institution A total of 5 institutions were represented in both questionnaires	Completed by 10 institutions	Free text responses were inductively coded in Word (Microsoft Office Professionals Plus 2019) and subsequently clustered according to keywords. Quantitative data underwent analysis and clustering in Excel. Administered in paper format at the second FutureBowl.
Open-ended Questionnaire 2	Gauge potential outcomes related to the transformation goals		Completed by 9 institutions	Administered in paper format at the third FutureBowl.
Research Diary	Document experiences and insights regarding CliCa's goals	--		Notes were discussed within the research team and used for the discussion. Important details of bilateral conversations were noted.
Interviews	Get information about transformation goals and long-term impacts	Selected actors with whom close contact was maintained and among whom changes were implemented in the institutions		Interviews (ranging 11–35 minutes long) were meticulously recorded, transcribed, and clustered according to the identified levers using the MAXQDA 24 software. One actor declined to participate in interviews but consented to respond to interview questions in writing; inquiries addressed in written form were incorporated into the clustering process. Starting with an opening question, what they still remember from the project, the interviewed actors were asked how CliCa supported them during the project's duration, whether the changes that occurred during the project period are still in place, whether further changes have been made, whether there is still contact with other actors from the network (for details, see Tables A3, A4, and A5 in the Appendix). Two years following the conclusion of CliCa, eight structured interviews were conducted via Zoom. Interviewed actors were asked to describe the changes initiated by CliCa and then implemented in the institutions; explicitly mentioned barriers were also coded.

sented in the following section. Steps 4 and 5 are included in the Discussion section. Throughout the project, the project team members assumed various roles, including those related to organization, moderation, and neutral mediation. On occasion, the project team members also acted as mediators, researchers, and speakers at the FutureBowls.

Step 1: Joint Identification of Research Needs

The primary objective of the Karlsruhe Real-World Laboratory for Sustainable Climate Protection (KARLA), where CliCa was located, was to pilot some of the urban climate protection measures from the Karlsruhe Climate Protection Concept 2030 (adopted in 2020) on a small scale, using a participatory approach, and integrating other social and environmental dimensions in addition to reducing CO_2 emissions. CliCa was selected as a transformation experiment[4] within KARLA through a participatory co-design process involving a series of coordination meetings, workshops, and a survey targeting at Karlsruhe citizens, climate protection experts from the Karlsruhe Institute of Technology (KIT), the municipal administration, and prospective project partners. KARLA was integrated into the infrastructure of the real-world laboratory District Future—Labor City, which operates in a transdisciplinary manner, fostering mutual learning and facilitating encounters at eye level (see also Ober et al., 2024) and leveraging its existing transdisciplinary infrastructure, expertise, and networks. For a more comprehensive understanding of the concepts of transformative and transdisciplinary research, refer to Fricke et al. (2023).

Step 2: Agreement on Expectations and Objectives

During the project's preparatory phase, the project team identified six levers (see Table 2) for a climate-friendly cafeteria. The selection was based on the ability of each lever to substantially influence a cafeteria's carbon footprint; degree of influence by operators or staff; and feasibility of implementation within the project timeframe. CliCa focused on practices that could be changed within a manageable timeframe, such as the selection of food and ingredients, rather than targeting changes to the kitchen or building infrastructure, which would require a more substantial investment. Five levers were mentioned as measures in the Karlsruhe Climate Protection Concept 2030 (E.1.8.); another lever (L06) addressing the guidelines of the DGE (The German Nutrition Society [DGE], 2021), which focus on the intersection of climate protection, sustainability, and health, was added during the course of the project.

Table 2. Synopsis of the Levers Addressed, and the Support Provided by the Climate-Friendly Cafeterias (CliCa) Project

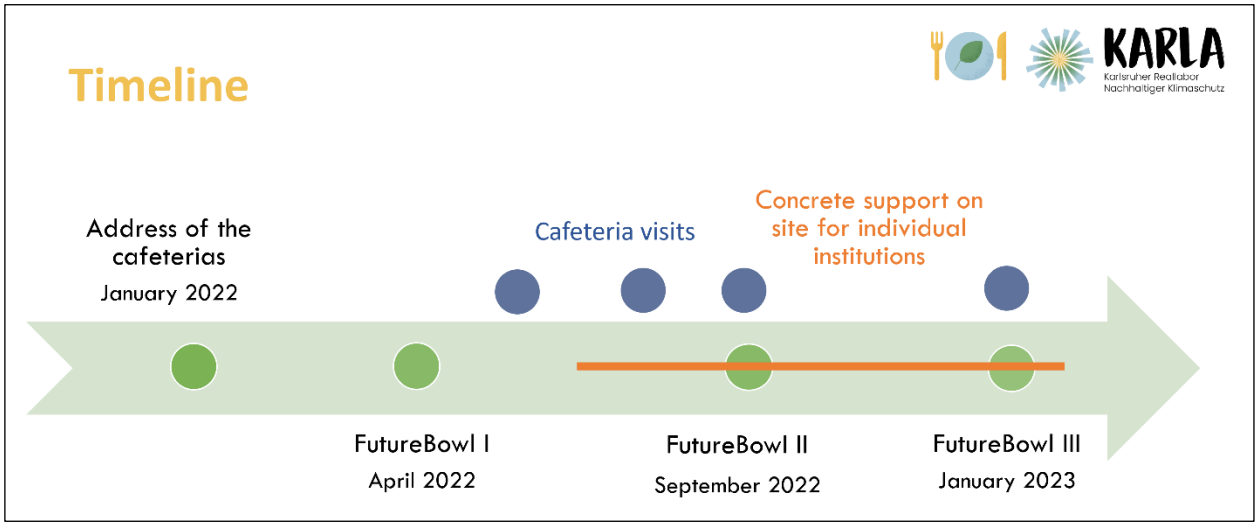
No.	Lever (L)	Support provided by CliCa
01	Avoid food waste	• Connecting with the Foodsharing initiative • Providing a concept for passing on leftover food to parents (daycare center)
02	CO_2 emissions accounting and communication	• CO_2 emission balancing of dishes using the tool Eaternity • Visualization of CO_{2eq} savings in the form of table displays
03	Local and seasonal food products	Providing a regional supplier list
04	Vegan and vegetarian meals/products	Providing information through a digital info hour
05	Take-away culture and reusable systems	Advice on different reusable systems
06	Organic and DGE certification	Organizing expert input at the FutureBowl from the State Center for Nutrition BaWü and the organic inspection entity in Karlsruhe

[4] The term 'transformation experiment' in KARLA refers to trying something out (an alternative, new processes, or new approaches) in a limited period of time. The aim of the experiment is to bring about at least temporary change and to examine the experiment in terms of its sustainability and mechanisms of action.

Step 3: Involvement of Actors and Establishment of Continuous Communication

One of CliCa's main tasks was to establish a network of relevant actors, and identify and document local examples of best practices. These examples include local cafeterias that act as pioneers of change (WBGU, 2011), setting a good example, and having the potential to serve as role models and transfer practical knowledge. After conducting a comprehensive investigation of the relevant local actors, a variety of individuals and organizations were contacted via email: municipal institutions, including kindergartens and schools; prominent corporate dining facilities; social institutions; and active individuals. The initial contact aimed to raise awareness of the project, encourage networking among interested parties, identify examples of local best practices, and provide interested actors with closer support in implementing sustainability measures in their cafeterias. The project team participated in various local action days on sustainable nutrition and held preliminary talks with interested actors. Approximately 40 interested institutions were added to an email distribution list, which was subsequently used for further communication. Notably, an individual from the city administration substantially facilitated the inclusion of municipal actors. The project website[5] provided detailed information on the individual levers. Throughout the project, various examples of best practices were disseminated, including cafeteria profiles, news articles, and materials designed to communicate the carbon footprints of different meals effectively. Additionally, related articles were published in the local newspaper, and a podcast episode was released. Individual consultations were conducted for four institutions. These included administering a survey to cafeteria guests in one cafeteria (not included in this article), conducting a survey on vegetarian offerings and demand in another, cooperating and consulting with the Foodsharing initiative for food pickups (particularly with regard to legal aspects), balancing the CO_2 emissions of several dishes, and providing counsel to another cafeteria on options for reusable items. The actors who participated in the transdisciplinary formats (e.g., FutureBowls and cafeteria visits; see Figures 1 and 2) included cafeteria operators, cooks, and kitchen or operations managers from seven municipal institutions, three scientific institutions, three social organizations, two associations, one major supplier, and municipal administrators from four different offices. These participants answered the questionnaires (see also the Method section). Consequently, the participants in this study represented a diverse range of backgrounds and experiences,

Figure 1. Timeline of the CliCa Project, January 2022–January 2023, Illustrating the Various Formats Applied (Including FutureBowls and Cafeteria Visits)



[5] KARLA website: https://www.reallabor-karla.de/klimafreundlicheKantinen.php

including cafeteria managers and individuals involved in municipal cafeteria operations.

Results

We first outline the barriers identified by participants in the FutureBowls. Then we present Clica's outcomes (implementations during the project's duration) and impacts (implementations after the project ended) to evaluate the transformation goal. This evaluation is informed by the responses of the actors to the second questionnaire and the findings from the follow-up interviews.

Barriers to Implementing the Measures

Ten distinct barriers to implementing measures of the levers were identified based on the questionnaires administered at the second FutureBowl (see Tables 3 and 4).

Barriers identified in total

The actors identified the substantial barrier 'Lack of acceptance' [B5], which is referenced 14 times and is particularly evident in the context of 'Increasing the range of vegetarian/vegan food' (7 codes). Additional substantial barriers that have been identified are [B8] 'Lack of/unclear framework conditions' (10 codes in total), [B1] 'Lack of money' and [B4] 'Higher price.' The barriers less frequently mentioned are [B10] 'Lack of incentives' and [B3] 'Lack of premises.'

Barriers identified per lever

The barrier [B5] 'Lack of acceptance' was identified seven times within the lever 'Increase the range of vegetarian/vegan food.' The most barriers were mentioned in relation to the lever 'Increasing the use of organically produced food' (different: 7; barriers in total: 12). The second largest number of different barriers was pointed in the lever 'Establishment of take-away and reusable systems' (different barriers: 6; 9 in total). A total of 9 barriers were identified in the lever 'Increase the use of local/seasonal foods' and 'Increasing the range of vegetarian/vegan food on offer.'

Implementations in the Actors' Institutions

Due to the fluctuating number of participants at the FutureBowls, the actors who had represented their institution at the third FutureBowl ($N = 9$) were asked to respond to a questionnaire regarding their awareness of a lever identified by CliCa, their subsequent engagement with the topic, and whether this had led to any changes in their institutions (see Figure 3, multiple answers possible). The lever 'Local and seasonal products' (L03) was not queried, as some measures were associated with measures in other levers (L04 and L06). The responses to the questionnaires indicate that the majority of the actors who were informed about a lever had continued to work on it. In each of the five levers measured, at least three institutions have

Figure 2. Impressions of the Third FutureBowl that Took Place in a Cafeteria

Source: Karlsruhe Transformation Centre (KAT).

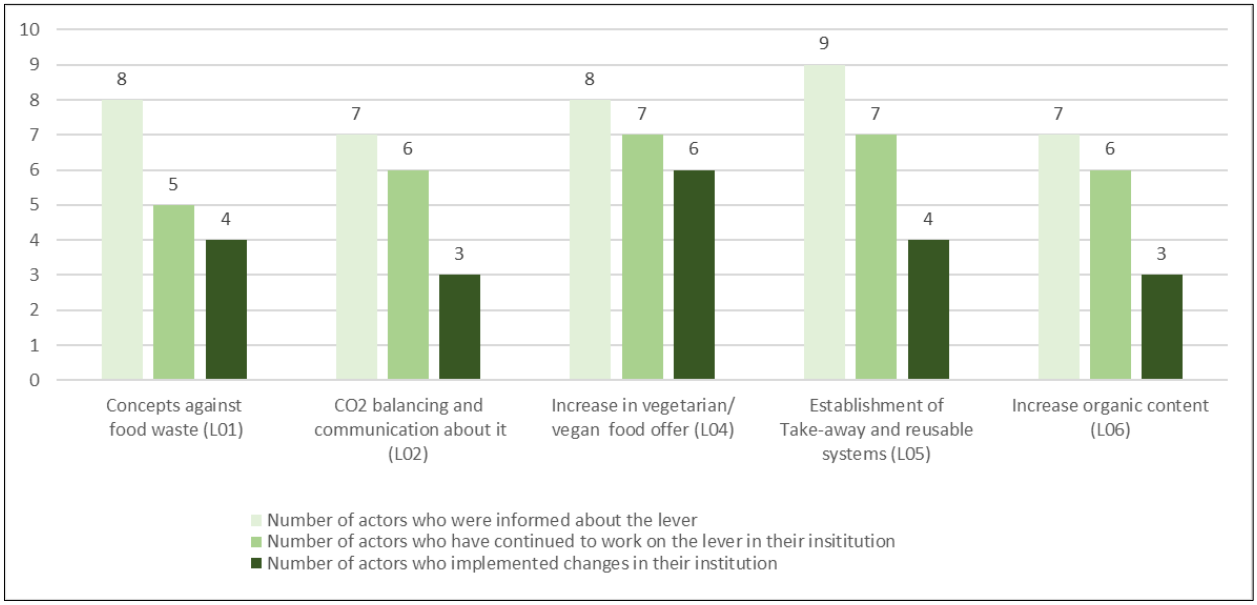
Table 3. Overview of the Barriers Identified, Accompanied by the Respective Code Number and Detailed Information Concerning Each Barrier

Code number	Barrier identified	Further description
[B1]	Lack of money for implementation	e.g., for organic certification
[B2]	Lack of suppliers or difficult market conditions	especially for local products
[B3]	Lack of premises	lack of space (especially storage space)
[B4]	Higher price that would affect consumers	
[B5]	Lack of acceptance among guests or employees	resulting in fear of guest migration, among other things
[B6]	Lack of time	e.g., to find new suppliers find out about certification options
[B7]	Lack of staff for the conversion and introduction of measures	e.g., communication options for CO_2 accounting restricted as a result
[B8]	Lack of/unclear framework conditions	very broadly defined, e.g. tendering procedures hinder the increase in the use of regional food; regionality cannot be considered in tendering procedures; limits of public procurement law; limits of own kitchen system or own infrastructure or in the reduction of food waste
[B9]	Lack of information	including lack of experience
[B10]	Lack of incentives	including the influence of the environment ("the others don't do it either"), lack of role models or lack of peer group

Table 4. Overview of Barriers Mentioned per Lever

	Barriers										Number of different barriers mentioned per lever	Number of barriers mentioned in total in a lever
Lever	B1: Lack of money	B2: Lack of suppliers/ difficult market conditions	B3: Lack of premises	B4: Higher price	B5: Lack of acceptance	B6: Lack of time	B7: Lack of staff	B8: Lack of/ unclear framework conditions	B9: Lack of information	B10: Lack of incentives		
Reduction of food waste (L01)						2		1	1		3	4
CO_2 balancing of dishes and communication about it (L02)						3	3		1		3	7
Increase the use of regional/seasonal foods (L03)		3		2	1			3			4	9
Increasing the range of vegetarian/vegan food on offer (L04)					7						1	7
Establishment of take-away and reusable systems (L05)	1				2	1		2	1	2	6	9
Implementation of organic certification by an approved organic inspection body (L06)	4	1	2					1		1	5	9
Increasing the use of organically produced food (L06)	2	1		3	1			3	1	1	7	12
Implementation of the DGE quality standard for catering (L06)		1			2		1				3	4
Number of mentions across all levers	8	7	2	8	14	8	6	10	5	4		
Number of mentions within one lever	1	2	3	4	5 to 7							

Figure 3. Implementations in the Actors' Institutions During the Term of the CliCa Project, Categorized by Lever (L)



implemented changes. Notably, six out of eight actors have implemented changes in the lever 'Increase of vegetarian/vegan food offer.'

Follow-up Interviews on Impacts after the Project's Ending and Barriers

In the interviews, we inquiried about the impact of CliCa (defined as implementations after the project's ending) related to five of the levers (Table 5). All interviewees reported implementations in at least one lever. A total of four interviewees reported implementations across four levers. The following implementations were mentioned: an increase of vegetarian or vegan ingredients and food (mentioned for four institutions); the introduction of weighing weeks to minimize food waste; a greater processing of leftover food; organic certification for individual product groups; and the introduction of a new reusable system. It is important to acknowledge that the authors of this study cannot presume that all of the observed changes can be attributed exclusively to CliCa's influence. In the first questionnaire, respondents were asked to specify which levers they had previously worked on. One-third of the respondents (representing 10 institutions) had previously mentioned working on 'implementation of organic certification by an approved organic inspection body,' 'increasing the range of vegetarian/vegan food on offer,' and 'increasing the use of organically produced food.' Note that the interviews indicated that it is not possible to distinguish between implementations that occurred during the project period and after the project period.

Discussion

The results indicate that both the levers and identified barriers are interrelated and can be addressed in combination. This is discussed in the following subsections, taking into account Steps 4 and 5 of the transdisciplinary process according to Ferretti et al. (2016). In addition, we discuss references to the educational goal. Lastly, we present the study's limitations and potential for future research.

Step 4: Formulation and Transfer of Research Results

The barrier [B1] 'Lack of money' is mentioned a total of eight times, especially for the lever 'Implementation of organic certification by an approved organic inspection body.' However, the project team demonstrated in the third FutureBowl that the costs associated with being certified organic are often lower than commonly assumed. This barrier

Table 5. Overview of the Outcomes and Impacts Identified in the Interviews, Conducted Two Years after the Project's Conclusion, Grouped by Measures per Lever

The statements listed in one cell in the 'Outcomes and impact' section correspond to the statements made by one of the actors interviewed. The measures currently under planning are indicated in **blue**. Challenges mentioned are displayed on the right. For further information, refer to Tables A1 and A2 in the Appendix.

Measure (Lever)	Outcomes and impact	Challenges
Against food waste (L01)	Cooperating with Foodsharing	
	Reusing leftover food (e.g., offering leftovers as salads the next day)	
	• Cooperating with Foodsharing and the public order office so that leftovers from a school are passed on to the church community • Cooperating between schools and Foodsharing since 2024	
	Regularly checking portion sizes and leftovers	
	Weighing and measuring food waste to identify areas for improvement	
CO_2 emissions accounting and communication (L02)	Balancing CO_2 emissions of individual dishes (supported by KIT) and communication about this in the weekly plan	• Staff missing • Too time-consuming
	Working to raise awareness among guests through communication via screens on sustainability and organic products	
Local and seasonal food products (L03)	Increasing the proportion of fresh products (in muesli) and products from own production for nutritional reasons	
	• Changing recipes and side dishes for individual dishes to integrate regional products • Reducing supply chains by sourcing more regional products	
Increase in the range of vegetarian/ vegan food (L04)	Offering more vegetarian products or menus; significantly increasing sales of vegetarian food	Meat substitutes are in demand by guests, but are not considered healthy as they are highly processed
	Promoting the vegetarian line even more	
	• Changing the menu: first, name the vegetarian options • Reducing meat consumption by offering more stews and goulash	
	• Increasing vegetarian and vegan dishes (instead of 1 out of 4 dishes, change to 2 out of 4 dishes; vegetarian share is 46%) • Offering vegetarian/vegan dishes first in the product portfolio	
	Training (in-house) for chefs	
Establishment of take-away and reusable systems (L05)	Establishing reusable systems for take-away food	Introduction of checkout/deposit system for reusable items difficult
	• Less packaging waste thanks to dispensers (e.g. for honey, jam and Nutella) • Paying more attention to bulk packaging	
	Requesting sustainable packaging in the tender	
	Introducing reusable systems instead of disposable	
	Introducing reusable boxes for a 5 euro deposit, in addition to disposable packaging	
	Introducing reusable systems is here to stay	
	Introducing reusable packaging for pizza	
	In 2025: Replacing the last single-use packaging with reusable packaging	
	Further reducing disposable packaging	

continued

Table 5 continued

Increase the organic share and DGE certification (L06)	• Increasing organic products (e.g. switch to organic pasta) • Contacting the organic certification body	Increase in prices
	Making all side dishes in patient catering of organic quality (previously was only salad)	At the same time that prices were increased due to the higher proportion of organic products, VAT was increased to 19% Healthy food is often not accepted by children, resulting in a high level of food waste
	Using more organic products (some products converted, such as jam, eggs, vegan spread)	
	Cafeteria has been certified organic, and 20% of the monetary value of goods is organic (mandatory for federal cafeterias since 2025)	
	Increasing organic share from 2% to 11.3% (as of 2025)	
	Increasing the proportion of organic products	
	Utilizing training courses for dishes according to DGE guidelines	
	Remodeling (new shelves for organic products), mainly for beans and pasta	
	Striving to offer some products in organic (pasta, lentils) Target: 50% organic	
Other changes and impacts	Networking as an important lever	
	• Lesson learned: No top-down approach. Important to talk to guests in order to gain understanding for changes • Creating awareness among chefs and employees	
	Exchanging with other cities/municipalities and within a city is important	
	• Communicating changes to guests is important • Delivery days reduced from 3 to 2 days through cooperation between distributors	
	Networking of different actors as particularly enriching	

therefore underscores the significance of stakeholder awareness in promoting climate-friendly transformations. A substantial amount of information and counsel is available, particularly from the state of Baden-Württemberg, which has set itself the ambitious goal of increasing the share of organic food to 40% in the state-run cafeterias by 2030 (State of Baden-Württemberg, 2024). However, the flow of information is limited. This example illustrates how the information flow plays a pivotal role in transformation processes. In particular, the state of Baden-Württemberg has the potential to assume a more prominent role by proactively promoting advisory programs and disseminating information. Furthermore, the barrier [B3] Lack of premises is specifically identified for this lever. The size of the individual cafeterias that participated in the questionnaire plays a particularly important role in this analysis. This could be due to the fact that organic foods must be stored separately from conventional foods, as outlined in Directive 2014/24/EU and the Regulation on Organic Food Service.

It is noteworthy that the barrier 'Lack of money' was mentioned only on two occasions in the context of the lever of increasing organic products. A paucity of financial resources is often identified as a primary impediment to adopting organic products in cafeteria kitchens (Braun et al., 2018; Filippini et al., 2018; Kretschmer & Dehm, 2021; Risku-Norja & Løes, 2017). This may be attributed to the fact that the kitchens surveyed are aware of the prevailing measures that can be adopted to mitigate the financial implications of higher purchase costs associated with organic products. For instance, utilizing seasonal organic products, reducing meat in dishes, increasing plant-based dishes and reducing food waste are common measures employed to compensate for higher purchase prices (Lassen et al., 2023).

In discussions with individual actors, we identified the effects of the COVID-19 (coronavirus) pandemic as a barrier or inhibiting factor in the implementation of climate-friendly measures. The global recession, which officially ended in 2022,

has had a substantial impact on this regard, as it has led to a considerable degree of uncertainty and has exacerbated the financial challenges experienced by certain actors. The considerable increase in remote work among some corporations due to the pandemic has resulted in a notable challenge for many cafeterias, as this transition has led to a decline in the number of individuals using the cafeteria facilities. According to the Federal Association of the German Food Industry (BVE, 2024), while the communal catering sector has not yet returned to the level of 2019 (the year before the coronavirus pandemic), it is gradually recovering.

The interviewees' statements regarding seasonal and local products align with the findings from other research projects. The integration of regional products is subject to legal impediments, as stipulated by the Public Procurement Act. The European Union's policy prohibiting discrimination indicates that local suppliers should not be accorded preferential treatment. The predominant supply structures in the public catering sector represent a substantial impediment to incorporating local and seasonal products. The following factors, in particular, restrict the regional availability of local products: more difficult market access for smaller regional (organic) producers; inconsistent supply structures; and inadequate processing structures for the requirements of communal catering (Braun et al., 2018; Kretschmer & Dehm, 2021). The most frequently mentioned barrier is 'Lack of acceptance by guests,' particularly with regard to offering vegetarian and vegan dishes. Consequently, guest demand should be a pivotal consideration in transforming cafeterias to promote healthier and more sustainable diets. Providing plant-based dishes is ineffective if guests at the counter opt for meat dishes. The guest's choice may be related to a lack of information about the health benefits of a plant-based diet (Simon et al., 2023), to 'neophobia'—the fear of trying something new—or to willingness to pay and the perceived value of the catering services themselves (Lopez et al., 2020). Nonetheless, cafeteria kitchens possess considerable potential to influence the manner in which they plan their menus and offer plant-based dishes. The fundamental principle that guides this endeavor is to create an impression on consumers through the quality and flavor of the products. Attractive and flavorful plant-based dishes have been identified as a 'critical enabler for change' (Graça et al., 2022) and are considered one of the key factors in the transformation to more sustainable public catering (Lopez et al., 2020). A multifaceted array of factors influences guests' acceptance of vegetarian dining options. These factors encompass aspects such as pricing, with vegetarian meals often being priced comparable to, if not more expensive than, meat alternatives. Other influential factors include the size of the portion, the perceived satiety after the meal, the gustatory experience, and the presentation of the dish. This encompasses elements such as the nomenclature of the dish and the availability of additional information regarding the provenance of ingredients or health-related benefits. We hypothesize that all the points mentioned, as well as encouraging guests, could influence the acceptance of guests with regard to a vegan or vegetarian food offer. Establishments could address these factors to improve demand for vegetarian and vegan food.

Public catering has been identified as playing a pivotal role in the transformation of the food system by its potential to reduce animal products and place greater emphasis on legumes, in accordance with the Planetary Health Diet. This approach also entails a substantial increase in the proportion of organic food and a further reduction in food waste. A further imperative for all actors, from catering facilities to consumers, is advancing a heightened appreciation for food, coupled with having a comprehensive understanding of the multifaceted factors influencing its production and subsequent pricing (Fischedick et al., 2021). It is evident that the institutions represented at the FutureBowls have already demonstrated a number of promising approaches.

To further advance sustainability in public catering, it is imperative to establish a broad alliance of actors. The absence of adequate structures in food procurement that align with the requirements of public catering necessitates engaging elements of the upstream value chain. In a similar vein, the downstream areas of food waste recycling can serve as a pivotal mechanism in achieving closed-loop recycling in the food sector (although the primary

focus in this context is on the prevention of food waste). Local authorities play a pivotal role in this regard, as they possess the capacity to establish political frameworks conducive to developing sales, bundling, and processing structures. Local authorities should also assume responsibility for fostering collaboration among actors along the value chain. Municipalities can establish long-term coordination structures that extend beyond the duration of individual projects and foster long-lasting contacts and networking. The government-funded organic model regions in the state of Baden-Württemberg, designed to strengthen regional organic value chains, offer instructive examples. These regions demonstrate that coordination fosters valuable networking opportunities. Having permanent positions is imperative to cultivating profound trust among stakeholders (Schramek et al., 2023). The necessity for so-called coordination centers has been a subject of discussion for a considerable period (Hoinle et al., 2025). Moreover, effective governance is imperative for their success. In 2024, the state of Baden-Württemberg issued an administrative regulation stipulating that food in public cafeterias operated by the state must be 40% organic and 75% sustainable by the end of 2030 (Ministry of Food, Rural Affairs and Consumer Protection, 2024). According to the provisions of this administrative regulation, sustainable food is defined as food with sustainable, transparent, and traceable supply chains. This is characterized by the use of short transport routes, the absence of genetic engineering in production processes, and the reliance on seasonal produce (Ministry of Food, Rural Affairs and Consumer Protection, 2024). The provisions involving transport routes and seasonality are an attempt to increase the regional share of food. Additionally, there are increasing levels of advisory services for cafeterias at both the national and state levels. This development may offer companies the opportunity to implement changes that could benefit them. The resources and events offered by the Baden-Württemberg State Center for Nutrition merit particular mention in this context.

Step 5: Reflection on the Research and Transdisciplinary Process

As is often the case with transdisciplinary and transformative research projects, the question of continuation has not yet been satisfactorily resolved. The transfer of successful activities, such as the networking events (FutureBowls), to individuals capable of continuing them has proven problematic and has not yet occurred, and maintaining stakeholder engagement in the post-project phase remains challenging. This was also an inherent problem in the project structure, as CliCa was only funded for one year. This issue is at least partially addressed by the further recruitment of additional projects; two current research projects[6] and additional local initiatives build on the results of CliCa.

It is imperative to reiterate that the participating actors in CliCa encountered disparate framework conditions (in terms of personnel, kitchen equipment, and economic and financial resources). While the fundamental challenges remain comparable, the scope of action and the degrees of freedom available to the actors vary. A subset of operators possesses their own kitchen facilities and receive subsidies to maintain low food prices. In contrast, other operators are subject to stringent procurement guidelines and are permitted to implement fundamental changes only every few years by inviting new contract agreements.

The responses to the questionnaires and the written and verbal feedback from the participating actors demonstrate that CliCa was able to encourage changes in the individual companies despite its one-year duration. The participants expressed their gratitude for the opportunities to establish professional connections and share their experiential knowledge. We posit that the "positive atmosphere" noted in the questionnaire getting at the communication on a personal level is pivotal in facilitating the exchange of ideas among practice partners engaged in transdisciplinary research, ensuring equitable collaboration. This approach encourages participants to share their concerns and

[6] Project "Transformation of the food system towards sustainability using the example of innovations for communal catering in the Upper Rhine region" (see https://www.itas.kit.edu/english/projects_labo24_icnern.php) and project "Co-Creation of Sustainable Food Supply Chains through Cooperative Business Models and Governance" (see https://www.sustainablefood-sc.org/index.php).

uncertainties, fostering a collaborative environment. This low-threshold exchange fosters a sense of solidarity among stakeholders in implementing climate protection initiatives, thereby addressing concerns and fostering collective action.

Addressing the educational goal

The educational goal was not operationalized and measured; however, there is evidence that CliCa has fostered a collaborative environment conducive to mutual learning, sharing of experiences, and implementing changes through the exchange of ideas, contributions, and materials. The participants stated on multiple occasions during the interviews that they learned a considerable amount both from the other participants and from the CliCa project. Example quotes include, "You have done a good job of imparting knowledge and sparking interest in a pleasant atmosphere"; "Thank you for the great work/It opened my eyes to a lot of things." However, what we have learned from CliCa is that raising the knowledge of cafeteria employees and understanding the guest perseptive require further attention. A paucity of training in the preparation of plant-based dishes for kitchen staff has been identified as a common issue in the literature (Lopez et al., 2020; Martin et al., 2022). Enhancing training and providing further education is therefore recommended (Martin et al., 2022; Risku-Norja & Løes, 2017; Schäfer & Haack, 2023). CliCa has created a video about enhancing vegetarian and vegan dishes; however, it does not delve into the subject of raising awareness among kitchen staff.

Limitations and Future Research

One limitation of this study is the variation and small number of participating actors; only a total of five institutions were represented through actors in both FutureBowls, at which questionnaires were handed out. The present study's participants are few in number (a small *N*), which is to be expected given the local transdisciplinary and transformative nature of the project and its relatively brief funding period. Consequently, the integration and analysis of the questionnaire results proved to be challenging. Furthermore, a more thorough examination of the perspectives of guests at cafeterias is warranted. For instance, surveys could assist in ascertaining how guests perceive the communication of CO_2 emissions related to dishes. Surveying guests about a wider range of vegan or vegetarian options could also be beneficial in the discourse surrounding climate-friendly public catering. Many cafeteria operators are concerned that guests do not want these options, without having concrete indications to support this claim. Further research is needed concerning the barriers identified in implementing the levers. A sustainable diet encompasses a variety of other sustainability issues, including increasing the use of fair-trade food, obtaining feedback from visitors to promote participation and co-determination, raising awareness among employees in the company, and addressing fair wages along the value chain. However, these aspects were only marginally addressed in CliCa and could be included in a follow-up transformative project. Further research is necessary to explore the implications of the external costs approach (which factors the long-term costs of environmental and climate damage into food prices), as the integration of external costs into pricing strategies could have long-term implications for pricing and dietary behavior.

Conclusion

The following key messages are derived from our analysis. 'Lack of money' was one of the most frequently mentioned barriers, particularly with regard to organic certification. In Germany, there is a wealth of information on this topic, but there is not enough flow of information. The most frequently cited barrier was 'Lack of acceptance,' particularly with regard to vegetarian and vegan options. Therefore, it is imperative to take guest demand into consideration when transitioning cafeterias to healthier, more sustainable menus. Nonetheless, cafeteria kitchens hold significant potential to shape menu planning and promote plant-based options.

In addition to the barriers identified, the effects of the coronavirus pandemic were identified as a barrier or inhibiting factor in implementing climate-friendly measures. The interviewees' perspectives on seasonal and local products align with the findings of other research, which indicate that the Public Procurement Act and EU non-discrimina-

tion policy impose legal restrictions on preferential treatment for local suppliers. The procurement challenges inherent to public catering demand engagement from the entire value chain. Local authorities should coordinate long-term networks, as evidenced by the organic model regions in the state Baden-Württemberg. Establishing permanent coordination roles is imperative for fostering trust among stakeholders. Effective governance is imperative for the success of such initiatives.

On a positive note, the participating actors in CliCa have shown that they can share pertinent practical knowledge with one another, empowering them to start implementing measures. The transformative results achieved are scalable and transferable to other cities. It makes sense to extend the scope of involvement from this transformation project to a diverse array of actors to catalyze transformative change. A network of different actors can lead to particularly fruitful outcomes if they are working on the same problems and if similar systemic conditions exist in terms of infrastructure, food, guests, and economic framework conditions. In such cases, transdisciplinary and transformative research projects that facilitate the networking of various actors and exchange of experiences are a viable option for fostering cooperation and trust among actors with diverse professional backgrounds.

We concur with the recommendation of the Ministry for the Environment (BMU, 2018) to promote climate-friendly catering as a cross-cutting issue in the government administration, as these entities are responsible for a significant number of cafeteria kitchens, including those in schools and daycare centers. Municipal administrations can function as catalysts in this regard, by facilitating the coordination of communication channels among various municipal offices and thereby fostering networks among different actors in municipal facilities. Climate-friendly nutrition—and more broadly, sustainable nutrition—is a subject that is pertinent to the future. Consequently, the implementation of a climate-friendly cafeteria will be influenced not only by the intrinsic motivation of individual players in out-of-home catering, but also by mounting pressure from the federal government, state, and local authorities.

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Appendix. Connecting Local Food System Actors for Climate-Friendly Public Catering

Table A1. Overview of Impacts that were Identified in the Interviews Conducted Two Years after the Project's Conclusion

The impact encompasses the changes that were implemented within the actors' organizations. The measures currently under planning are indicated in **blue**. Challenges mentioned are indicated in **red**; measures to be implemented in the future are indicated in grey.

Actor	Measures against food waste	CO_2 emissions accounting and communication	Increase the organic share	Increase in the range of vegetarian and/or vegan food	Establishment of take-away and reusable systems	Other changes and impacts
A01 • Canteen in municipal office • Canteen guests: high physical strain, increasingly male	Cooperation with Foodsharing	No, because too time-consuming.	• Increase in organic products (e.g. switch to organic pasta) • Contacting the organic certification body • Remodeling (new shelves for organic products), mainly for beans and pasta	More vegetarian products or menus; significant increase in sales of vegetarian food	Take-away food established in reusable systems	• Increasing the proportion of fresh products (in muesli) and products from our own production for nutritional reasons • Networking as an important lever (**Q1, see Table A2**)
A02 • Patient catering and canteen in hospital		Working to raise awareness among guests through communication via screens on sustainability and organic products	All side dishes in organic quality (previously only salad) in patient catering	• Even more promotions for the vegetarian line • Training (in-house) for chefs		• Lesson learned: No top-down approach. Important to talk to guests in order to gain understanding for changes • Creating awareness among chefs and employees (**Q2**)
A03 • Small welfare organization • Canteen guests: Young people	Reuse leftover food (e.g. offer leftovers as salads the next day)		More organic products (some products converted, such as jam, eggs, vegan spread)	• Changing the menu: name the vegetarian options first • Reduce meat consumption by offering more stews and goulash	• Less packaging waste thanks to dispensers (e.g. for honey, jam and Nutella) • Pay more attention to bulk packaging	

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Actor	Measures against food waste	CO_2 emissions accounting and communication	Increase the organic share	Increase in the range of vegetarian and/or vegan food	Establishment of take-away and reusable systems	Other changes and impacts
A04 Coordination of municipal school catering	• Cooperation with Foodsharing and the public order office so that leftovers from a school are passed on to the church community • Cooperation between schools and food sharing since 2024				• Request sustainable packaging in the tender • Introduction of checkout/deposit system for reusable items difficult **(Q3)**	• Healthy food is often not accepted by children, resulting in a high level of food waste in some cases • Exchange with other cities/municipalities and inner-city exchange important **(Q4)**
A05 • Canteen of a company			Strive to offer some products as organic (pasta, lentils)		• Introduction of re-usable systems instead of disposable **(Q5)** • In 2025: Replace the last single-use packaging with reusable packaging	• Communication of changes to guests is important **(Q6)** • Delivery days reduced from 3 to 2 days through cooperation between dealers
A06 • Canteen of a federal authority with its own tenant • Mixed clientele, including senior citizens from the neighborhood			• Canteen has been certified organic, 20% of the monetary value of goods are organic (mandatory for federal canteens since 2025) • At the same time as prices were increased due to the higher proportion of organic products, VAT was increased to 19% **(Q7)**		Introduction of re-usable boxes for a 5 euro deposit, in addition to disposable packaging	

Actor	Measures against food waste	CO_2 emissions accounting and communication	Increase the organic share	Increase in the range of vegetarian and/or vegan food	Establishment of take-away and reusable systems	Other changes and impacts
A07 • Large canteen, employee catering at large research company	• Regularly check portion sizes and leftovers	Staff missing (**Q8**)	• Increase in organic share from 2% to 11.3% (as of 2025)	• Increase in vegetarian and vegan dishes (instead of 1 out of 4 dishes to 2 out of 4 dishes, vegetarian share is 46%)) • Vegetarian/ vegan dishes are offered first in the product portfolio • Meat substitutes are in demand by guests, but are not considered healthy as they are highly processed	• Introduction of reusable systems is here to stay • Further reduce disposable packaging	• Change recipes and side dishes for individual dishes to integrate regional products • Reducing supply chains by sourcing more regional products
A08 Canteen of a municipal administrative unit	Weighing and measuring food waste to identify areas for improvement	Balancing of CO2 emissions of individual dishes (supported by KIT) and communication about this in the weekly plan	• Increasing the proportion of organic products • Target: 50% organic • Increase in prices (**Q9**)		• Introduction of reusable packaging for pizza	• Networking of different actors as particularly enriching (**Q10**) • Utilization of training courses for dishes according to DGE guidelines

Source: Authors' own compilation.

Table A2. Actors' Quotations from the Interviews to Illustrate the Findings of Table A1
Challenges mentioned are indicated in **red**.

Code Number	Quotations from the interviews
Q1	*Because I can't do everything on my own. Sometimes you need an idea, sometimes you need an address. … It's good to have people who are already a bit further along, where you can get help.*
Q2	*To restore awareness there, because only they can sell it well.*
Q3	*Some really great things were presented, but many things are simply very, very cost-intensive. … The student basically has to pay a deposit for such reusable systems. Yes, and our housekeeping staff are not allowed to collect anything.*
Q4	*I always say that not everyone needs to reinvent the wheel, but can also learn from others, right?*
Q5	*… to communicate this to the customer. Because that's often our problem, I'll say in quotation marks, that you then also have customer acceptance. Why do we no longer have disposable items? Why do we no longer have coffee cups that you can take away?*
Q6	*And now, after three years in total, we've also had good feedback, simply that people are happy to use them.*
Q7	*… it has the same turnover and at higher prices. So there must have been fewer guests.*
Q8	*I simply don't have the manpower to balance the courts.*
Q9	*If it's double the price, that's fine. But if you're paying almost three times the price, that's just not possible. You can't get away with that.*
Q10	*So it was really extended from kindergartens to schools, to canteens, to company restaurants. … So it was an exchange from both sides. And it was simply fruitful, because you were always one step ahead.*

Source: Authors' own compilation.

Table A3. Questionnaire on Drivers and Barriers

Please tick [check] the boxes in the first three columns (multiple answers possible).
Which of these levers …
… have you worked with in the past?
… are you currently working with?
… do you want to work with in the future?
Please answer the following questions in brief:
Where do you see hurdles to implementation (such as lack of incentives, financial support, guidelines)?
A. What helped you to implement the lever?
B. Alternatively: What would you need to be able to address or implement the lever?

Table A4. Questionnaire on the Effects of the Project

Question 1. Lever: … • Were you informed about this lever by the 'Climate-friendly canteens'? • Did you then continue to work on the lever in your company/institution? • Has this led to a change in your business/institution? • When effects are visible, what do they look like in concrete terms? [Free text] • Why did addressing this issue have no effect? [Free text]
Question 2. Which two levers are most important for your business/institution in terms of climate protection?
Question 3. How did you find the canteen visits? [very helpful/helpful/neutral/not helpful/not at all helpful]
Question 4. How did you find the FutureBowls format? [very helpful/helpful/neutral/not helpful/not at all helpful]
Question 5. What did you think of the materials provided as part of the project? (Posters, displays on carbon footprinting, presentation on measures for vegetarian offerings) [very helpful/helpful/neutral/not helpful/not at all helpful]
Question 6. In your opinion, what should be retained for similar projects in the future? [Free text]
Question 7. If an offer/element of the climate-friendly canteens could be made permanent or retained within the framework of KARLA, which offer should this be in your opinion? [Free text]
Question 8. Is there anything else you would like to share with us? Was there anything you particularly liked or disliked? [Free text]

Table A5. Questions from the Semi-Standardized Interviews

Question 1. What do you remember, what has stayed with you? How did CliCa support you?
Question 2. Are the changes that arose during the project period still in place?
Question 3. Have you continued to pursue the topics you set out to address?
Question 4. Have you implemented further concrete changes on other topics after the project period?
Question 5. Do you continue to exchange ideas with others/maintain existing contacts?
Question 6. Is there still interest in nutrition topics and networking?

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Scaling local food: A literature review on the organization, benefits, and challenges of food hubs

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Abstract

Direct-to-consumer channels have developed as alternatives to conventional agri-food systems characterized by long supply chains, market concentration, and limited connections between producers and consumers. Yet despite their potential, these channels face significant limitations that constrain their expansion and keep them largely confined to niche markets. In response, food hubs have emerged as intermediaries that aggregate and distribute products from multiple farms, enabling small- and medium-sized producers to reach institutional buyers while preserving the goals and values of local food systems. Synthesizing evidence from 34 peer-reviewed empirical studies, this review consolidates a dispersed body of research by clarifying the organizational and marketing structures, financing approaches, and documented impacts of food hubs. In doing so, the review shows that food hubs should be understood not simply as alternative distribution channels but as organizational intermediaries whose viability depends on the complex coordination of logistics, revenue streams, stakeholder relations, and economic and social objectives. It also highlights persistent challenges in farmer coordination, institutional market stability, and financial resilience that

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Authors' Note

The findings presented in this study are derived from a chapter of a report previously prepared by the authors (Mundler et al., 2025).

underscore the difficulties of sustaining food hubs and scaling local food systems.

Keywords
food hubs, farm-to-institution, supply chain coordination, local food systems, institutional procurement

Introduction

For more than two decades, direct-to-consumer channels such as farmers markets, on-farm sales, and community supported agriculture (CSA) programs have multiplied as strategies to reconnect producers with consumers (Enthoven & Van den Broeck, 2021; Low et al., 2015; Micheels & Boecker, 2017). Often framed as alternatives to the industrial food system, such channels promote social embeddedness through shorter supply chains and production transparency (Enthoven & Van den Broeck, 2021; Hinrichs, 2000). As such, they have been credited with strengthening farmer-consumer relationships while delivering economic and social benefits (Brown & Miller, 2008; Hinrichs, 2000; Kneafsey et al., 2013; Mundler & Laughrea, 2016).

However, research suggests that direct marketing channels encounter structural limits, as they require significant labor, generate low revenues, and remain confined to narrow markets (Azima & Mundler, 2022; Hardesty & Leff, 2009; Mount, 2012; Park, 2015). For small- and medium-sized farmers, reliance on these channels constrains growth and places heavy demands on their time and resources, often resulting in self-exploitation (Bruce & Som Castellano, 2017; Galt, 2013; Park, 2015). Additionally, in the U.S. and elsewhere, growth in direct-to-consumer channels has slowed in recent years, underscoring the difficulty of sustaining such models at larger scales (O'Hara & Benson, 2019; Stobbe, 2023; U.S. Department of Agriculture, National Agricultural Statistics Service [USDA, NASS], 2022).

These limitations have sparked interest in new distribution models that preserve local food values while increasing returns and market access for small- and medium-sized farmers (Blay-Palmer et al., 2020; Dimitri et al., 2019; Renkema & Hilletofth, 2022). Among the most prominent models are food hubs, which have garnered increased attention among scholars and policymakers (Barham et al., 2012; Levkoe et al., 2018; Matson et al., 2015). Food hubs are commonly defined as intermediaries that aggregate and distribute products from multiple farms, with the dual goal of expanding markets for producers and improving consumers' access to local food (Barham et al., 2012; Kneafsey et al., 2013). Food hubs are distinguished from direct-to-consumer outlets by their ability to pool logistical resources and administrative functions, allowing them to serve intermediate buyers, including restaurants, specialty grocery stores, schools, and hospitals (Matson et al., 2015). In this review, we use "institutional clients" and related terms as shorthand for this broader set of buyers. By channeling local products through these buyers, food hubs create a model that is one step removed from direct sales yet still anchored in the principles of the local food movement (Barham et al., 2012; Levkoe et al., 2018). This positioning allows them to operate between conventional distributors and direct marketing arrangements, combining broader reach with a continued emphasis on food proximity and community values.

The development of food hubs also reflects broader debates on how to scale up local food systems while preserving their territorial and social embeddedness (Blay-Palmer et al., 2020; Kneafsey et al., 2013; Renkema & Hilletofth, 2022). By pooling marketing and distribution functions, food hubs can provide small- and medium-sized farms with the infrastructure needed to reach otherwise inaccessible institutional markets, including trucks, cold storage, processing and packaging equipment, and IT systems (Levkoe et al., 2018; Matson et al., 2015). At the same time, their emphasis on institutional procurement can create new challenges, such as meeting regulatory requirements, ensuring consistent supply, and coordinating among diverse producers (Barham et al., 2012; Levkoe et al., 2018).

Research on food hubs is growing but remains fragmented across diverse themes and empirical contexts (Dimitri et al., 2019; Renkema & Hilletofth, 2022). To date, this body of research has not been systematically evaluated, underscoring

the need for a comprehensive review of empirical studies to clarify the role of food hubs in scaling and supporting local food systems (Dimitri et al., 2019; Enthoven & Van den Broeck, 2021; Renkema & Hilletofth, 2022).

This article addresses this gap by conducting a literature review of food hubs, guided by the following questions: (1) How do food hubs organize their logistics and marketing? (2) What legal structures, stated goals, and staffing profiles characterize food hubs? (3) What are the benefits of food hubs for farmers and communities? (4) What roles do external (e.g., grants) and internal (e.g., private capital, membership fees) financing play in food hub development? (5) What challenges hinder the growth and sustainability of food hubs?

The remainder of the article is structured as follows: The next section outlines the methodology used to identify and screen relevant studies. We then present the results, organized around the five research questions. The Discussion and Conclusion section situates the findings within broader debates on the sustainability of local food systems and considers future directions for research.

Applied Research Methods

For this study, we conducted a rapid review, a form of knowledge synthesis that follows the same general procedures as systematic reviews but uses streamlined search and screening protocols to address time and resource constraints (Moons et al., 2021; Tricco et al., 2015). While rapid reviews are less resource-intensive than systematic reviews, they still require a rigorous and transparent methodology (Haby et al., 2016; Moons et al., 2021). Rapid reviews are especially valuable when evidence must be generated quickly to support policymaking (Garritty et al., 2021).

As shown in Table 1, we selected inclusion and exclusion criteria to assess study relevance based on a working definition of food hubs from the literature (Diamond & Barham, 2012; Horst et al., 2011). This ensured the exclusion of studies that might have used the term for unrelated platforms, such as food banks, food terminals, supermarkets, or other corporate aggregators. We also limited our review to studies drawing at least in part on quantitative or qualitative data, excluding purely conceptual discussions of food hubs. Following Garritty et al. (2021), we restricted the number of databases consulted and limited the search to articles published in scholarly journals, meaning that gray literature was excluded. These choices aligned with our rapid review protocol, which required limits on scope and sources. Additionally, the review was limited to studies published between 2003 and 2023, the year in which the literature search was conducted. The cutoff of 2003 was chosen to reflect the rapid evolution of local food systems over the past two decades and the relatively recent emergence of food hubs.

Two databases were selected for the searches:

Table 1. Inclusion and Exclusion Criteria for Studies on Food Hubs

Inclusion criteria	Exclusion criteria
Focuses on food hubs defined as intermediaries that aggregate and distribute products from multiple producers	Uses “food hub” to refer to unrelated entities, such as food banks, food terminals, supermarkets, and other corporate aggregators
Involves marketing to institutional clients (e.g., schools, hospitals, specialty grocery stores)	Describes only direct-to-consumer models
Presents quantitative or qualitative data	Purely conceptual papers, commentaries, or theoretical models
Addresses at least one of the five research questions	Does not address any of the research questions
Peer-reviewed journal articles	Gray literature, reports, or non–peer-reviewed sources
Published in 2003 or later	Published before 2003
English or French	Other languages

Web of Science and ABI/INFORM Global. We then formulated search terms related to food hubs (see Table 2) and included truncation (*) to capture lexical variants. As noted, our criteria incorporated a working definition of food hubs to exclude studies that might use the term in unrelated contexts. Similarly, it was important not to overlook studies that evaluated food hubs without explicitly using the term or that used alternative terms we had not anticipated. Consequently, in addition to "*food hub*," we included keywords closely related to food hub activities (e.g., "*farm-to-school*").

The search strategy was further enhanced by pairing terms. For instance, we paired "*procurement*" and "*food*," requiring a maximum of five words between the terms (to capture variations such as "*procurement of food*" and "*public food procurement*"). For all pairings, we limited results to studies that also contained "*farm,*" "*producer*," or "*local*."

Figure 1 contains the PRISMA flow chart summarizing the screening and selection process, which was managed using the Covidence software platform. After removing duplicate records, we screened the titles and abstracts using the criteria in Table 1, adopting an inclusive approach so as to only exclude clearly irrelevant articles (Lefebvre et al., 2019). The full texts of the remaining articles were then assessed for eligibility. Following these two screening stages, 34 studies satisfied all criteria and were included in the final review.

We then created a fillable template in Covidence with five text fields, each corresponding to one research question. If a study addressed a question, the relevant passages were copied into the corresponding field; if not, the field was left blank. This approach allowed us to analyze articles deductively using predefined thematic categories. After data extraction, we exported the content to Microsoft Excel and conducted an inductive analysis to identify cross-cutting themes and insights. The results of this assessment are presented in the following section.

Results

Most studies were conducted in the U.S. (n = 30), with smaller numbers carried out in Canada (n = 1) and France (n = 2), and one study drawing on data from 15 European countries. Although the review spans the period from 2003 to 2023, the earliest included study dates from 2011. Publication activity has increased markedly since 2018, reflecting growing scholarly interest in food hubs.

The 34 studies reviewed here do not constitute a uniform sample of food hubs. Rather, they include single- and multiple-case studies, national survey- or directory-based analyses, policy reviews, and related empirical studies in which food hubs are examined as part of broader local and regional food systems. Where reported, the number of hubs considered per article ranges from one or two in several detailed case studies to dozens or hundreds in larger multi-hub samples and national survey- or directory-based analyses. We therefore treat the reviewed literature as evidence of the range of food hub models and issues examined in prior scholarship, rather than as a countable census of distinct food hubs. Accordingly, throughout the review, statements about food hubs should be understood as referring to the hubs examined in the studies cited, rather than to food hubs generally.

Table 2. Search Strategy and Keywords Used in the Rapid Review

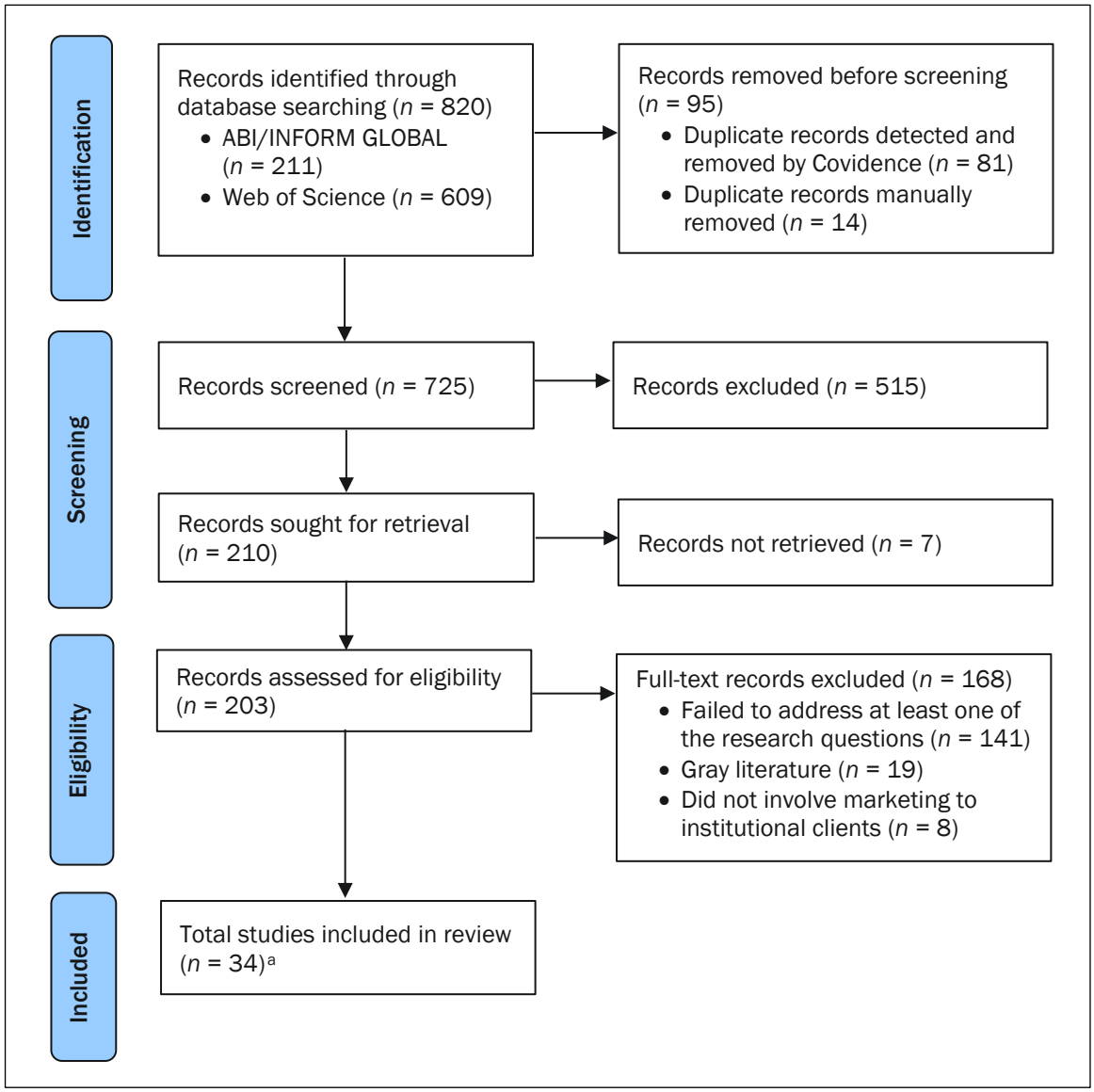
Core terms		Additional search terms
("*food hub**" OR "*farm-to-institution**" OR "*farm-to-school**" OR "*farm-to-hospital**" OR "*farm-to-restaurant**")		N/A
OR		
(*procurement* NEAR/5 *food**)	AND	(*farm** OR *producer** OR *local**)
OR		
(*institution** OR *public** NEAR/5 *foodservice**[a])	AND	(*farm** OR *producer** OR *local**)

Logistics and Marketing Operations

Food hubs operate under a range of business models that differ in product focus, scale of operations, customer profiles, and organizational networks. From a marketing perspective, many hubs combine wholesale sales to institutional clients with direct-to-consumer initiatives, such as CSA programs (Schmidt et al., 2011). Nearly half of surveyed U.S. food hubs also marketed at least some products through their own retail outlets (Fischer et al., 2015a). Pricing practices vary accordingly, with institutional clients often benefiting from lower rates due to economies of scale (Schmidt et al., 2011).

Most surveyed U.S. food hubs reported annual revenues below US$500,000 (Fischer et al., 2015b), although a small number of long-standing organizations that predate the term "food hub" recorded much larger sales volumes (Fischer et al., 2015a). The COVID-19 pandemic and resulting closures of

Figure 1. PRISMA Flow Chart of the Study's Selection Process



[a] Thirty-five articles remained after full-text screening, but two articles by the same authors presented almost identical findings and were therefore merged in the final count.

schools and restaurants significantly disrupted hub operations, pushing many hubs to pivot, at least temporarily, to direct-to-consumer channels. These disruptions also spurred the creation of interhub partnerships to balance surpluses and shortages caused by COVID-19–related market shocks (Fardkhales & Lincoln, 2021).

Product diversification has also accelerated. While fruits and vegetables predominate, a growing number of hubs market meat and poultry, and some even extend their offerings beyond farm products, as in the case of a Georgia hub that pairs farm produce with items from local food artisans (Entsminger, 2020; Furman & Papavasiliou, 2018; Jablonski et al., 2011).

Certain marketing routines appear across the literature. Typically, hubs update weekly product lists with prices and quantities and share them with clients via phone, email, or online platforms (Feenstra & Hardesty, 2016; Jablonski et al., 2011). Client orders are then consolidated and communicated back to farmers (Hyland & Macken-Walsh, 2022). Cleaning, organizing, and packaging may be done on-site or handled by farmers in accordance with the standards set by institutional buyers (Schmit & Severson, 2019). Farm-to-hub transportation arrangements vary, with some hubs requiring farmers to deliver directly while others rely on employees, subcontractors, farmer volunteers, or shared drop-off points, such as producers' refrigerated warehouses, farmers markets, or the offices of extension agencies (Cleveland et al., 2014; Rogers & Fraszczak, 2014).

Upon arrival, produce is inspected, and items failing to meet standards are returned (Schmit & Severson, 2019). In the studies reviewed, we did not identify alternative outlets for rejected products, such as processors or other buyers. Farmers unable to provide regular volumes may be excluded, with the option to return once deliveries become more consistent (Cleveland et al., 2014). Quality and volume requirements are typically more stringent than in direct marketing channels, meaning food hubs often rely on medium-sized producers capable of delivering regular quantities (Brislen, 2018). However, the reviewed literature gives limited attention to how hubs accommodate farms of different sizes or levels of supply consistency.

Because food hubs often receive the same product from multiple farms, different arrangements are used to coordinate marketing. When hubs handle both certified products (e.g., organic) and noncertified products, the latter are sold separately to clients who do not require certification (Schmit & Severson, 2019). Additional quality control measures are sometimes implemented. For instance, large supplies of the same item may be pooled by quality, with similar-grade products sold together; producers then receive the average selling price (Schmit & Severson, 2019). This strategy prevents farmers with lower-grade products from mixing them with higher-grade ones to obtain a premium. Even when batches are consolidated, however, produce may be delivered in labeled boxes to ensure traceability and marketing transparency (Feenstra & Hardesty, 2016).

Deliveries to clients usually occur once or twice weekly, and most produce reaches customers within 48 hours of harvest, a time frame that is essential for many institutional kitchens (Cleveland et al., 2014; Hyland & Macken-Walsh, 2022; LeBlanc et al., 2014). Orders may be delivered by hub employees, volunteer farmers, or subcontractors, or collected directly from the hub by institutional client staff (Knigge et al., 2016; Rogers & Fraszczak, 2014). Alternatively, orders can be sent to collection points (Hyland & Macken-Walsh, 2022; Jablonski et al., 2011).

Financial and marketing practices further distinguish hubs from conventional distributors. For instance, many pay farmers upon delivery, a practice uncommon in conventional supply chains but seen by hub managers as a way to build trust (Furman & Papavasiliou, 2018; Schmit & Severson, 2019). The final payment to farmers typically follows product sales, minus handling costs. Some hubs also implement noncompete clauses, which restrict farmers from supplying institutional clients directly (Motzer, 2019), although managers may lift these restrictions when direct sales are more practical. In California, for example, one food hub connected its farmers and institutional buyers when proximity made direct delivery more efficient (Cleveland et al., 2014). However, the study in question did not specify whether these transactions remained within the

hub's system or occurred directly between farmers and buyers.

Competition management also differs across hubs. Some hubs list only the lowest-priced supplier for each product (Feenstra & Hardesty, 2016), while others avoid this practice to limit rivalry among farmers and maintain quality standards (Cleveland et al., 2014). Pricing strategies can also vary. In hubs with strong social objectives, farmers set prices, and preferential pricing or bargaining is discouraged (Cleveland et al., 2014; Feenstra & Hardesty, 2016; Jablonski et al., 2011; Pesci & Brinkley, 2022). However, managers may advise farmers on adjustments to ensure that prices align with market realities and to allow hubs to apply mark-ups that cover overhead costs (Cleveland et al., 2014; Feenstra & Hardesty, 2016). Reported margins range from 20–25% (Motzer, 2019) to around 30% (Feenstra & Hardesty, 2016; Jablonski et al., 2011). Some evidence suggests that these rates are higher than those of conventional distributors (Feenstra & Hardesty, 2016).

Collaboration with farmers on crop planning is also common and is designed to reduce waste and guarantee reliable supplies (Cleveland et al., 2014; Feenstra & Hardesty, 2016; Schmidt et al., 2011; Schmit & Severson, 2019). Generally, these efforts are based on good-faith commitments rather than formal contracts (Schmit & Severson, 2019). Additional strategies are sometimes adopted to mitigate production risks. For instance, Cleveland et al. (2014) report on a California food hub that focused on six produce items, which allowed for better production forecasts and easier order planning for institutional customers. Some hubs go further by coordinating staggered harvests across farms to stabilize supplies (Schmit & Severson, 2019).

Infrastructure choices depend on hub size, age, and resources, as well as the availability of subcontractors. Smaller hubs tend to rent facilities and contract out transport, whereas larger ones often own infrastructure and subcontract only for longer-distance deliveries (Schmit & Severson, 2019). For younger hubs, mobile cold storage units have proven a cost-effective alternative to permanent infrastructure (Hyland & Macken-Walsh, 2022; Knigge et al., 2016).

Hubs also increasingly process products, either in-house or through third-party contractors, which extends the marketing season and reduces waste by allowing the sale of imperfect produce (Martinez, 2016; Thompson & Stinnett, 2018; Wen & Connolly, 2022). In many cases, institutional buyers demand semi-prepared fruits and vegetables due to limited in-house processing equipment (Rogers & Fraszczak, 2014).

The geographical area served by hubs varies, as some cover whole regions or administrative territories, whereas others draw from farmers within a specific radius, highlighting the flexible definition of "local" (Cleveland et al., 2014; Rogers & Fraszczak, 2014). Many hubs also emphasize transparency by listing farmer names, farm locations, and production methods on packaging, information that institutional buyers often share with clients (Conner et al., 2020; Feenstra & Hardesty, 2016). However, expanding distribution can complicate this individual attribution. While branding products under a hub's label has been suggested as a solution (Motzer, 2019), some institutional buyers may remain skeptical of such labeling and may prefer to know the specific farm source (Conner et al., 2020). These preferences suggest that the social dimension of direct sales and the importance of farmer-consumer relationships remain significant even for institutional clients (Pesci & Brinkley, 2022; Rogers & Fraszczak, 2014).

Legal Structures, Goals, and Staffing in Food Hubs

Food hubs typically pursue both economic and social objectives. In the 2013 National Food Hub Survey, 52% cited farmer support and 49% cited local food in their mission statements (Fischer et al., 2015a). Additional objectives include food access (22%) and improving human health (60%), while educational activities are also common, including public awareness about food systems issues (56%) and nutrition or cooking education (47%) (Fischer et al., 2015a). Many hubs also commit to sourcing from small- and medium-sized farms (Nelson & Landman, 2020; Shariatmadary et al., 2023). Lastly, some hubs aim to supply disadvantaged neighborhoods (Rutz et al., 2018) or support minority farmers and other marginalized

groups (Nelson & Landman, 2020; Rutz et al., 2018).

Legal structures vary: Hoey et al. (2018), drawing on the U.S.-based 2017 National Food Hub Survey, report that nationally 42% of food hubs are nonprofits, 37% are for-profits, and 21% operate with mixed legal models, such as public-private or university/community partnerships. Hubs are shaped by their mission and activities, as well as the expectations of participating stakeholders and clients (Saul et al., 2021), and some adopt dual legal structures to accommodate this diversity. For instance, a New York hub created a for-profit food distribution platform for its institutional clients and a nonprofit entity to run its anti-hunger program (Jablonski et al., 2011). Farmers can also influence hub governance, although organizational preferences may diverge. Schmidt et al. (2011), for instance, recount the case of a hub in the U.S. Midwest where some producers advocated for a cooperative model, while others preferred to remain independent suppliers rather than participate directly in hub governance.

Nonprofit incorporation is common when hubs combine economic and social objectives (Hoey et al., 2018). LeBlanc et al.'s (2014) Vermont case studies show that nonprofit food hubs may begin as grassroots initiatives with limited paid staff, infrastructure, and farmer participation. By contrast, other hubs in their sample operated through umbrella organizations that provided staff support and resources, while farmer engagement occurred through formal mechanisms such as annual meetings and board representation.

Adequate staffing is essential for hubs: most employ at least five workers, either on a year-round or seasonal basis (Fischer et al., 2015b; Motzer, 2019). However, start-up hubs often struggle to fund staff, and while volunteers can fill gaps, core operations require paid employees (Schmidt et al., 2011). To compensate, some start-ups turn to consultants or advisory boards of community members and professionals who contribute expertise free of charge (Schmidt et al., 2011). Assistance may include writing business plans and offering technical and marketing advice to participating farmers (Hyland & Macken-Walsh, 2022).

In addition to general management duties, hub employees are expected to cultivate relationships with buyers, highlight producer identities, and differentiate the hub from conventional distributors (Feenstra & Hardesty, 2016). Staff thus play a crucial intermediary role by relaying feedback and information between farmers, institutional clients, and funders, a task that requires both sales expertise and strong communication skills (Conner et al., 2020; Feenstra & Hardesty, 2016; Pesci & Brinkley, 2022; Schmit & Severson, 2019). Trust and regular exchanges between managers and farmers also give farmers the confidence that their output will be sold, allowing them to adjust their crop choices to meet institutional demand (Brislen, 2018; Cleveland et al., 2014). Open communication also makes it easier for farmers to anticipate orders and flag production constraints, such as weather- or pest-related issues (Brislen, 2018).

Advantages of Food Hubs for Farmers and Communities

Food hubs generate documented benefits for local economies, producers, and rural regions. For instance, Jablonski et al. (2016) found that a US$1 million increase in demand for food hub products generates gross output and employment multipliers of 1.75 and 2.14, respectively. Moreover, when opportunity costs are included, the output and employment effects, while smaller, remain positive, at 1.57 and 1.94, respectively, with limited displacement of spending in other sectors, estimated at US$0.11 per dollar.

Food hubs also play a role in supporting "agriculture of the middle," namely, medium-sized producers who are too large to rely solely on direct sales yet too small to use conventional distributors (Brislen, 2018; Stevenson et al., 2011). Farmers report increased sales, income, and production from hub participation (Conner et al., 2018; Jablonski et al., 2011; Motzer, 2019; Schmidt et al., 2011). They also value the prompt and consistent payments associated with such platforms and report satisfaction even when sales to hubs remain a modest component of overall farm revenue (Conner et al., 2018). In some regions, food hubs have been credited with agricultural resurgence, enabling producers to earn a living from farming and, when demand is steady, to lease new land for

expanded production (Cleveland et al., 2014; Motzer, 2019). At the same time, individual food hubs, even well-established ones, may reach only a limited share of farms in a region. Consequently, while hubs can contribute to rural development, their capacity to reverse broader patterns of rural decline remains limited without wider systemic interventions (Motzer, 2019).

Farmers report that food hubs allow them to access institutional customers that would otherwise be out of reach (Conner et al., 2018; Hyland & Macken-Walsh, 2022; Jablonski et al., 2011). Food hubs make this possible by taking on numerous administrative responsibilities that individual farmers would otherwise have to manage themselves, including customer relations, invoicing, and delivery (Motzer, 2019). This delegation of tasks reduces the number of hours farmers spend on marketing compared to direct sales channels (Jablonski et al., 2011). Hubs are also credited with offering more secure outlets for perishable produce, enabling farmers to minimize financial losses and reduce food waste (Cleveland et al., 2014). On the institutional buyer side, the aggregation of supply from multiple farms ensures greater product availability and lessens the impact of farm-level crop failures (Schmidt et al., 2011).

Access to institutional clients through hubs is especially beneficial for beginning farmers (Brislen, 2018; Jablonski et al., 2011; Motzer, 2019), as it provides a reliable source of income and reduces uncertainties associated with direct sales, such as unstable earnings and low retention rates in CSA programs (Brislen, 2018). Similarly, producers who inherit family farms are often drawn to food hubs as a way to sustain their agricultural legacy while diversifying their client base (Brislen, 2018).

Food hubs also provide technical assistance and training opportunities for members. For instance, in a content analysis of 50 food hubs in U.S. metropolitan areas, Shariatmadary et al. (2023) found that about one quarter of the hubs offered technical assistance or training to farmers, including support for sustainable production. Other services include training for producers seeking organic certification or developing new business skills (Jablonski et al., 2011; Motzer, 2019). At a hub in New York State, for example, staff organize regular meetings among farmers, managers, and institutional clients, providing farmers with mentorship and feedback on issues such as invoicing, labeling, and market opportunities (Jablonski et al., 2011). Similarly, in a California hub, members receive guidance on institutional buyers' expectations regarding packaging, post-harvest handling, and sanitary practices (Feenstra & Hardesty, 2016).

Participation also enhances the market credibility of farmers, with many reporting that hubs promote their products effectively and strengthen their capacity to collaborate with other buyers (Conner et al., 2018). By participating, farmers signal reliability and familiarity with industry standards, in some cases enabling them to sell directly to institutional customers outside the hub's network (Brislen, 2018).

Lastly, food hubs play a bridging role between rural producers and urban markets. For many small- and medium-sized farms, particularly those run by new entrants, these markets are difficult to penetrate without intermediaries (Brislen, 2018). Hubs fill the gap by training farmers in food handling and safety; arranging bulk purchases of supplies (e.g., packaging); and raising awareness about urban consumer preferences, which can be opaque to producers (Brislen, 2018). This support is also visible during preseason planning, when some hubs work with members to align crop choices and volumes with anticipated demand (Schmidt et al., 2011).

Financing Food Hubs

Food hubs draw on diverse sources of finance, especially in the start-up phase. External support can include grants, low-interest loans, or other forms of nonrepayable capital disbursed by public agencies or philanthropic foundations (Fischer et al., 2015b; Hoey et al., 2018; LeBlanc et al., 2014). In addition to revenue from sales, food hubs may rely on supplementary financing streams such as donations, farmer membership fees, and contributions from founders (Entsminger, 2020; Fournier et al., 2020; Rysin & Dunning, 2016; Saul et al., 2021). Hubs may also benefit from in-kind support provided by post-secondary institutions, local agencies, volunteers, or charitable organizations (Fournier et al., 2020; Saul et al., 2021). A hub's

legal status can influence funding eligibility, with many adopting nonprofit status to qualify for public or private grants (Jablonski et al., 2011).

USDA programs, as well as state- and regional-level initiatives, indirectly support food hubs by encouraging institutions, such as schools and hospitals, to source local or organic food (Hoey et al., 2018; Roche et al., 2014; Rogers & Fraszczak, 2014). As mentioned, the COVID-19 pandemic created severe operational challenges for hubs following the closure of schools and restaurants. Federal emergency programs in the U.S. provided relief either directly to hubs or indirectly through subsidized programs in which hubs participated. This support helped mitigate losses and allowed hubs to redirect efforts toward direct sales and other initiatives until institutional client demand resumed (Saul et al., 2021).

In a 2019 national survey, one third of U.S. food hubs relied on external financial assistance to sustain operations (Shariatmadary et al., 2023). Economically, such funds help bridge the gap between conventional market prices and the higher per-unit production costs of small- and medium-sized producers, enabling hubs to offer competitive prices to customers (Perrett & Jackson, 2015). They also offset operational costs, which are proportionally higher for hubs than for large conventional distributors that benefit from economies of scale (Fischer et al., 2015b; LeBlanc et al., 2014). Likewise, external funding can be used to hire personnel and support the development of business plans, websites, promotional materials, or farmer training programs (Saul et al., 2021; Schmidt et al., 2011).

This reliance on external financial support has been criticized on the grounds that lags between grant applications and disbursements create management challenges (Jablonski et al., 2011). Hub managers themselves acknowledge that dependence on outside funding can mask structural problems with profitability (Saul et al., 2021). Producers and distributors unaffiliated with hubs also argue that financial support distorts competition by giving supported hubs an advantage over businesses that do not receive comparable assistance (Perrett & Jackson, 2015).

Researchers remain divided over the required duration of outside financial assistance. Some argue that it should be temporary or should naturally taper off within three to five years as hubs move toward self-sufficiency (Fischer et al., 2015b; Rysin & Dunning, 2016). A study in Michigan illustrates this pattern: sampled hubs operating for one year or less relied on external funding for 53% of their revenue, while those active for three years or more had reduced that share to 28% (Hoey et al., 2018).

Others contend that continuous external funding may be justified as an investment in public goods that generates positive externalities (Rysin & Dunning, 2016; Saul et al., 2021). The argument is that hubs often take on responsibilities neglected by public authorities, such as providing extension services for small- and medium-sized farmers or addressing food insecurity in disadvantaged communities. Consequently, the need for funding to pursue economic and social objectives may reflect the failure of public institutions and policies to adequately support equitable food access and regional food infrastructure, rather than shortcomings in the hub model (Hoey et al., 2018; Nelson & Landman, 2020). External financial assistance may also serve longer-term governance objectives in certain contexts, as illustrated by a case in France where local authorities maintained funding to influence a hub's development (Fournier et al., 2020).

Scholars debate the effects of external aid, such as grants, on hub decision-making. As mentioned, Jablonski et al. (2011) emphasize the risks created by funding delays, but others argue that outside financial support creates a safer environment for experimentation. According to this perspective, such contributions enable adaptive learning, midcourse corrections, and risk-taking, all of which foster innovation and allow hubs to function as laboratories for sustainable solutions (Hoey et al., 2018; Schmidt et al., 2011). Some researchers also stress that other funding sources are usually limited, especially during the start-up phase (Saul et al., 2021). For instance, introducing or raising farmer membership fees is rarely viable given the modest revenues of many participants. Likewise, private investment is often deterred by the uncertain or low returns from hub activities (Fournier et al., 2020).

As noted, many food hubs pursue both social and economic goals, a balance that can be hard to

sustain without external support (Fischer et al., 2015b; Hoey et al., 2018; Rutz et al., 2018). Indeed, a 2013 U.S. survey found that hubs undertaking "plus activities," such as nutrition or cooking education, were more likely to rely on outside financial assistance (Fischer et al., 2015a). Likewise, in their Michigan study, Hoey et al. (2018) found that nonprofit food hubs relied most heavily on external funding, drawing an average of 70% of their revenue from grants, donations, or government sources, compared with 46% for mixed-model hubs and 0% for for-profit hubs. Nonprofit hubs also reported the highest average number of socially oriented activities. Four hub partners or managers interviewed for the same study suggested that dependence on external funding could be reduced through cross-subsidization, whereby profits from higher-margin markets or product sales help cover the costs of social initiatives that operate at a loss. This strategy, however, was framed as difficult to sustain because it depended on hubs expanding into more profitable markets, attracting customers able to pay higher prices, or broadening their product range to include nonlocal foods.

Obstacles to Growth and Sustainability

Despite their potential to strengthen local food systems, several factors limit food hub development. Martinez (2016), drawing in part on the 2015 National Food Hub Survey, notes that food hubs often face numerous challenges, including working with multiple producers, managing delivery logistics, securing enough product supply to meet buyer demand, and obtaining the capital and infrastructure needed for growth. Stakeholders in a study from Georgia also attributed constraints on food hub development to difficulties sourcing enough local products year-round and to coordination challenges among growers, prospective food hub managers, and buyers (Munden-Dixon et al., 2015). Institutional clients' limited awareness of food hubs in their communities can further restrict growth (Fournier et al., 2020).

Recruiting farmers can be challenging, as those committed to direct marketing and opposed to industrial agriculture may view hubs as conventional intermediaries to avoid (Rogers & Fraszczak, 2014). Others accustomed to large-scale distributors may be discouraged by the smaller volumes and perceived informality of food hubs. Conflicts can also emerge within hubs because smaller farms often prefer limited sales at premium prices, while larger ones seek higher volumes at discounted prices (Schmidt et al., 2011). Managing this diversity in farmer profiles and expectations increases workloads and the potential for conflict (Fournier et al., 2020; Jablonski et al., 2011). For instance, Motzer (2019) describes the tensions that arose in a Montana hub after new members were required to produce less profitable crops, which fostered perceptions of favoritism and exclusion. Hubs can also strain relations with nonparticipating farmers who may view such platforms as competitors for markets (Motzer, 2019; Perrett & Jackson, 2015).

Another obstacle is that farmers may prioritize direct sales over hub deliveries, with one study finding that even highly committed producers used hubs mainly to sell surplus produce (Furman & Papavasiliou, 2018). Farmers also struggle to balance the product diversity required for direct-to-consumer sales with the higher-volume specialization expected by food hubs.

The literature identifies additional challenges for both participating farmers and clients. For instance, producers face tight deadlines for harvest and delivery, uncertain order volumes, and concerns over the loss of individual brand identity and connections to clients (Cleveland et al., 2014; Schmidt et al., 2011; Thompson & Stinnett, 2018). Farmers also report low prices (compared to direct sales) and low volumes (compared to conventional chains), particularly in hubs that balance fair pricing with social missions (Cleveland et al., 2014; Conner et al., 2018; Hoey et al., 2018; Rutz et al., 2018).

As mentioned, farmers who join a food hub are often required to sign noncompete clauses, which can create tensions with managers. For established growers in the Montana food hub analyzed by Motzer (2019), this restriction meant relinquishing previously held retail accounts, including profitable or long-standing ones, although the article does not specify whether this applied to retail accounts not served by the hub. Less-established

producers in the hub also viewed these restrictions as potentially limiting the growth of their businesses. In Georgia, a manager even concealed the identity of institutional clients to prevent participating farmers from bypassing the platform and selling directly (Furman & Papavasiliou, 2018). Such conflicts can ultimately undermine the cooperative, noncompetitive relationships on which food hubs depend.

Institutional buyers commonly cite constraints such as limited product availability, seasonality, and their own insufficient storage, which can constrain their ability to increase purchases from food hubs. Similarly, delivery schedules can be inconvenient, and institutional clients with limited staff available for processing may struggle to accommodate larger volumes of produce when food hubs do not provide processing services (Conner et al., 2020). Seasonality itself often leads to demand fluctuations that hubs may struggle to navigate, such as when schools close for holidays (Fournier et al., 2020). Collaboration is also constrained because public and semi-public institutions often face budgetary restrictions, contract requirements, and bidding processes that can be difficult for food hubs and producers to manage (Conner et al., 2020; Schmit & Severson, 2019).

Food hubs serve both large and small institutional clients, and each category offers distinct advantages and limitations. Serving large buyers can reduce delivery frequency and transport costs, but it can also force hubs to compete with conventional distributors (Cleveland et al., 2014). Moreover, reliance on a small number of large clients can lead to dependency issues. These relationships can also be unstable, as contracts with schools, hospitals, and other public institutions frequently depend on time-limited public funds (Fardkhales & Lincoln, 2021). Meeting the production, handling, processing, and storage standards of such buyers poses another barrier, especially for smaller hubs (Schmit & Severson, 2019). By contrast, smaller customers, such as restaurants, specialty stores, and childcare centers, typically impose fewer requirements and allow hubs to diversify their revenue sources. However, managing numerous small deliveries can increase costs and operational complexity (Rutz et al., 2018).

Other barriers to hub growth include unstable external funding that can undermine long-term planning (LeBlanc et al., 2014), as well as shortages of infrastructure, including trucks, warehouses, processing facilities, and IT capacity. For example, many hubs depend on volunteers rather than IT professionals to build websites, which can result in technical issues and lost sales, while the absence of electronic payment systems can create cash flow delays when customer payments are late (Jablonski et al., 2011).

Human-resource constraints can further weaken performance. As noted by Entsminger (2020), founders of start-up hubs often lack management experience or a clear understanding of how hubs should function, reflecting a broader scarcity of accessible information and best-practice guidance (LeBlanc et al., 2014). Reliance on volunteers can also be risky due to differences in reliability and skill levels (LeBlanc et al., 2014).

Financial viability depends heavily on achieving sufficient sales volumes. Rysin and Dunning (2016) estimate that annual sales of approximately US$800,000 are required to break even, while Fischer et al. (2015b) place the threshold at US$600,000. Profitability also reflects expenditure patterns. Unprofitable hubs devote twice the share of revenues to overhead costs, reducing the amount available for product purchases, while profitable hubs spend around 15% on personnel and 70% on farm products, a distribution similar to that of conventional distributors. In unprofitable hubs, payroll consumes a larger share of expenditures, creating a cycle of low purchasing capacity and stagnant revenues (Fischer et al., 2015b; Rysin & Dunning, 2016).

Population density constitutes an additional barrier to growth. According to Cleary et al. (2019), a minimum population of about 182,000 residents is necessary to sustain a hub, as additional hubs can dilute revenues and undermine the viability of existing platforms. This suggests that external support and funding can unintentionally foster oversaturation, underscoring the need for coordinated growth to prevent duplication by multiple hubs offering identical services (Fournier et al., 2020). Cleary et al. (2019) also note that higher levels of social capital reduce the minimum population

threshold for profitability, indicating that hubs are more viable in communities with strong cohesion and public support for local agriculture.

Discussion and Conclusion

This study contributes to scholarship on local food systems by examining the organization of food hubs, their legal structures and objectives, the benefits they provide to farmers and communities, the financing mechanisms that support them, and the challenges they face. By synthesizing the evidence base to date, our findings can inform the development of policies and practices to support the growth of such platforms. In addition, the review offers insights into where further research is needed to advance our understanding of the role of hubs in building resilient and equitable food systems.

Our findings suggest that food hubs have the potential to strengthen local food systems but face persistent obstacles to long-term sustainability. For instance, they demonstrate an ability to adopt diverse marketing and organizational arrangements based on local contexts and are often motivated by both economic and social objectives. Participation in hubs also provides documented benefits for farmers and agricultural regions. At the same time, growth is constrained by difficulties in recruiting and coordinating farmers and stakeholders, the demanding requirements and unstable purchasing patterns of institutional buyers, and challenges in generating the sales volumes needed for financial viability.

As highlighted in this review, debates over external funding feature prominently in the literature, and their policy implications warrant attention. Most researchers ultimately stress the need for pragmatism, arguing that long-term funding should not be equated with failure, given the multiple objectives food hubs often pursue. As illustrated by the case study from France (Fournier et al., 2020), funding may also serve as an instrument of public control, underscoring the political dimensions of external assistance for food hubs.

Food hubs that receive financial support should document their outcomes to maintain transparency and public trust. This can be achieved through periodic performance evaluations, which enable midcourse corrections and the efficient use of resources (Nelson & Landman, 2020). While setting multiple economic and social objectives is not inherently problematic, hubs should avoid overcomplicating operations and engaging in mission creep, particularly when resources are limited (Hoey et al., 2018).

Beyond the question of external funding, another debate concerns whether food hubs challenge or reinforce existing food systems. Some critics argue that food hubs are not transformative but instead maintain the status quo (Perrett & Jackson, 2015). Direct-sales channels, by contrast, are explicitly designed in opposition to conventional modes of production and distribution. According to this perspective, food hubs are simply mechanisms for improving value chains and providing farmers with access to new markets at competitive prices. A counterargument is that food hubs, given their function as intermediaries, should not be judged by the same standards applied to direct marketing. Moreover, as growth in direct-to-consumer sales slows (O'Hara & Benson, 2019), food hubs represent a complementary strategy for expanding market opportunities for small- and medium-sized producers, while also supplying institutions with local food.

Appraising food hubs also requires consideration of their nonmonetary impacts, including the relationships they foster among supply-chain stakeholders (Cleveland et al., 2014). As Rogers and Fraszczak (2014) note, hubs operate as more than market intermediaries; they create spaces where farmers, staff, and institutional customers can meet, exchange perspectives, and develop trust, although the literature also notes that these relationships, at times, can become strained. For farmers, participation not only facilitates the sharing of professional challenges and peer learning but also reinforces a sense of belonging to a collective effort (Motzer, 2019).

Our findings also point to possible directions for the future evolution of food hubs. First, food hubs could develop more explicitly as regional platforms rather than solely as intermediaries for aggregation and distribution. This would involve adopting stronger systems for demand forecasting and crop planning, staggered production, expanded

processing capacity, and even coordination among multiple hubs or shared infrastructure, particularly where localized production, institutional purchasing requirements, and limited resources constrain individual hub growth. Second, food hubs could further develop the relationship-based and transparent forms of intermediation already adopted by some hubs, while continuing to centralize logistics, invoicing, food safety compliance, and delivery. These practices include co-branding, showcasing farm profiles, buyer-producer meetings, and platform-based ordering systems that make participating farmers more visible to institutional clients. Such arrangements could combine the efficiency of intermediated aggregation and distribution with the closer producer-buyer relationships that characterize direct marketing channels.

One limitation of our review was the exclusion of gray literature. While this choice is permissible under rapid review protocols (Tricco et al., 2015) and helped maintain a focus on peer-reviewed sources, it may have excluded practical insights from the field that are not captured in the academic literature, including more recent National Food Hub Survey data. Future reviews would therefore benefit from incorporating gray literature sources to capture a broader range of perspectives, as well as more recent data.

Looking ahead, several research gaps also warrant attention. First, racial equity remains underdeveloped in peer-reviewed food hub research. Although some studies in our sample briefly touched on related issues, including support for minority farmers and underserved communities, few examined racial equity as a central analytical focus. Future research should therefore examine how food hubs engage with racialized communities and minority farmers, and whether they address or reproduce inequities in food systems.

A second gap concerns the limited scholarly attention given to food hubs involved in meat processing and distribution. The regulatory and infrastructure demands associated with such hubs suggest that their operations differ in important ways from conventional produce-focused hubs. Accordingly, a fuller understanding of hubs specializing in meat products would broaden the empirical base of food hub scholarship and inform policymaking in a sector where small- and medium-sized livestock producers often face significant barriers to market access, including limited slaughtering and processing facilities (Syukron & Su, 2023).

Another area requiring attention is organizational diversity. While nonprofit food hubs receive the bulk of scholarly attention, over half of U.S. food hubs operate as for-profit or hybrid entities (Fischer et al., 2015a). Consequently, more work is needed to understand how for-profit hubs differ from their nonprofit counterparts in terms of structure, funding, and community impact. Such research would shed light on which organizational models best support economic viability and social objectives.

Future research could also examine how prices charged by food hubs compare with those of conventional distributors. Such comparisons would need to account for differences among institutional clients, including whether food is resold to end consumers through restaurants or specialty grocery stores, or served in settings such as schools and hospitals, where consumers may not pay directly for the food. Finally, as our results show, research on food hubs remains concentrated in the U.S., which limits understanding of how such platforms function in other geographic and cultural settings. Documenting such cases would clarify the potential of hubs to strengthen local food systems in other industrialized countries, while also expanding the evidence base needed for designing policies tailored to local contexts.

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Challenges and barriers in food supply chains: A scoping review of needs assessments in the southern border counties of Texas and New Mexico

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Abstract

Food supply chains in the southern border counties of Texas and New Mexico face persistent disruptions driven by environmental, infrastructural, socioeconomic, and policy-related stressors. Understanding these challenges is crucial for informing coordinated efforts to enhance regional food systems. We conducted a scoping review to identify and synthesize evidence on challenges and barriers affecting food supply chains in the region. Peer-reviewed articles and grey literature published between 2014 and 2024 were searched and appraised using the AACODS framework. Nine sources met the inclusion criteria and were analyzed to characterize cross-sectoral challenges

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spanning production, aggregation, distribution, and retail systems. Findings reveal a set of interconnected barriers shaping regional food supply chains. Environmental stressors, including drought, aquifer depletion, extreme heat, and conflicts over water governance, limit agricultural productivity and increase reliance on external suppliers. Infrastructure gaps, particularly shortages of aggregation hubs, cold storage facilities, and transportation networks, further constrain efficient movement of goods. Cross-border dependencies, such as inspection delays, regulatory shifts, and policy uncertainties at U.S.–Mexico ports of entry, exacerbate systemwide vulnerabilities. Finally, retail-access inequities in rural colonias, where many communities rely on small outlets with limited refrigeration and constrained inventory capacity, interact with structural affordability barriers, limiting the availability and variety of fresh, perishable foods. Across sectors, food supply chains in the Texas–New Mexico border region are shaped by cascading challenges that span environmental stressors, infrastructure deficits, and cross-border policy volatility. Upstream disruptions in water governance, labor stability, and aggregation capacity amplify transportation costs and downstream retail constraints. These findings identify actionable priorities for regional decision-makers, including strategic investment in cold-chain and aggregation infrastructure, coordinated binational port and inspection processes to reduce spoilage risk, and workforce-stabilization policies that support small- and midscale producers.

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challenges, barriers, food supply chains, southern border counties, Texas, New Mexico

Introduction

Food supply chains play a central role in supporting food security, economic stability, and community well-being by connecting production, processing, distribution, and retail systems (Linnenluecke & Griffiths, 2010; Ponis & Koronis, 2012). However, global food systems are increasingly exposed to disruptions from climate change, market shocks, policy shifts, and environmental pressures, creating significant risks for regions that are already socio-economically and geographically vulnerable (Bhamra et al., 2011; Katsaliaki et al., 2022). The southern border counties of Texas and New Mexico present one such region where environmental and socio-economic challenges converge to influence food production, aggregation, and distribution. In this review, colonias refers to residential communities along the U.S.–Mexico border that often lack basic infrastructure such as potable water, sewer systems, paved roads, drainage, and safe housing (Texas Office of the Attorney General, n.d.).

Proximity to the U.S.–Mexico border introduces additional complexities, as local food systems depend heavily on cross-border trade flows, migrant labor, and binational supply chains (Lozano, 2022). Shifts in immigration policies, transportation regulations, and trade agreements have direct con-

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sequences on availability and affordability of food in the region (Cruz-Sánchez et al., 2024). The region also faces intensifying climate-related stressors, including prolonged drought, declining flows of the Rio Grande, aquifer depletion, and extreme heat, which constrain irrigated agriculture, increase production volatility, and elevate costs across regional supply chains (Intergovernmental Panel on Climate Change, 2015; Viva Doña Ana Initiative, 2015; Waldman, 2021). These environmental pressures are compounded by competing demands for water and limited irrigation resources, issues further complicated by the region's legal and policy frameworks governing water rights (Lashmet, 2018; Serrano, 2020).

Because food supply chains operate as complex adaptive systems (CASs), disruptions at one point, such as droughts, labor shortages, or transportation bottlenecks, often cascade through interconnected sectors, amplifying risks across production, processing, and retail levels (Ivanov et al., 2014; Surana et al., 2005). For small and medium-sized enterprises (SMEs), which comprise a significant portion of the regional food economy, these challenges are particularly acute, as they often lack the necessary infrastructure, technical capacity, and financial resources to manage disruptions effectively (Bak et al., 2023; Hammond et al., 2013). To address these systemic issues, investments in infrastructure, workforce development, and technological innovation have been widely recognized as priorities for strengthening supply chain stability (Kamalahmadi & Parast, 2016; Zsidisin et al., 2005). Expanding cold storage, aggregation capacity, and transportation infrastructure can enhance distribution efficiency, while adopting digital tools and real-time monitoring systems can improve coordination and response to shocks (Linnenluecke & Griffiths, 2010; Pajić et al., 2024).

Although this review was undertaken during the planning phase of the Rio Grande Colonias Regional Food Business Center (RGC-RFBC), its findings underscore structural constraints that extend beyond infrastructure development alone. Specifically, environmental water limitations, cross-border regulatory volatility, and labor instability may constrain the effectiveness of aggregation-focused investments unless addressed in tandem. Thus, the review serves not only as a planning input but also as a critical lens through which regional investment strategies can be reassessed and refined. Using a systematic search of major databases and regional needs assessments published between 2014 and 2024, we aimed to consolidate existing evidence on food supply chain challenges in this region. Our research question was: *What are the main challenges and barriers faced by various sectors of the food supply chain across the southern border counties of Texas and New Mexico?*

By synthesizing fragmented peer-reviewed and grey literature, this review advances understanding of food supply chain challenges in border regions by identifying cross-sector structural vulnerabilities and illustrating how environmental, infrastructural, and policy constraints cascade across interconnected sectors. This integrative analysis reframes food supply chain resilience as a governance and coordination challenge rather than solely as an infrastructure deficit, thereby informing regional planning strategies that account for upstream–downstream linkages. Conceptually, this study contributes to food systems literature by applying and contextualizing the complex adaptive system (CAS) framework to U.S.–Mexico border food supply chains—a setting largely absent from existing CAS-informed supply chain scholarship. The review suggests that in binational border food systems, cascading disruptions are governed not only by internal network properties but also by exogenous regulatory volatility (trade and immigration policy) and transboundary resource constraints (shared water governance), a configuration that existing CAS frameworks have not yet fully addressed. By surfacing these border-specific dynamics, the study offers insights that may inform supply chain resilience theory and offers a transferable analytical lens for other binational food corridor contexts globally.

Methods

The review proceeded through four stages: systematic searching, eligibility screening, credibility appraisal, and structured thematic analysis.

Search Strategy

This study employed a scoping review methodology to map the breadth and characteristics of avail-

able evidence on food supply chain challenges in the southern border counties of Texas and New Mexico. A scoping approach was selected because the literature base in this region is sparse and heterogeneous, and includes a substantial body of grey literature. Rather than evaluating intervention effectiveness, the objective was to identify structural barriers, cross-sector patterns, and evidence gaps across production, aggregation, distribution, and retail segments. A scoping framework was therefore more appropriate than a systematic review, which is typically designed for a narrowly defined intervention or outcome assessment.

A comprehensive search was conducted across PubMed, Scopus, Web of Science, Medline Ovid, AGRIS, and Google Scholar to identify peer-reviewed literature. Given the limited number of peer-reviewed studies specific to the southern border region, the search was expanded to include government reports, policy documents, and publications from non-governmental organizations. Targeted searches of state agency websites, institutional repositories, and regional organizations were also conducted.

The search strategy employed a combination of keywords and terms, including "food systems," "food industry," "food supply chains," "Texas," "New Mexico," "border counties," "southern border counties," "challenges," and "barriers." Boolean operators (AND, OR) were used to refine the search results appropriately. This approach ensured a comprehensive and systematic identification of relevant sources that addressed the research question. For example, a representative Boolean string applied in PubMed and Scopus took the form: ("food supply chain" OR "food system" OR "food industry") AND ("Texas" OR "New Mexico" OR "border counties" OR "southern border") AND ("challenges" OR "barriers"). Equivalent strings were adapted to the controlled vocabulary and field tags of each platform (e.g., MeSH terms in MEDLINE/Ovid, AGROVOC descriptors in AGRIS). Grey literature was identified through structured targeted searches of state and regional agency websites (e.g., Texas Department of Agriculture, New Mexico Department of Agriculture, USDA regional offices), the websites of regional food systems nonprofits and planning organizations, and institutional repositories. Supplementary grey literature was identified via a snowball approach in which the reference lists of all included sources were reviewed to surface additional documents not captured through database or website searches.

The search period was restricted to 2014–2024 to capture contemporary supply chain conditions. Search terms included combinations of "food systems," "food supply chains," "Texas," "New Mexico," "border counties," "challenges," and "barriers," using Boolean operators (AND/OR) to refine results. Sources were included if they: (1) focused on food supply chains or food systems in Texas or New Mexico; (2) addressed structural challenges or barriers affecting production, aggregation, distribution, or retail sectors; and (3) were published in English between 2014 and 2024. Sources were excluded if they did not address the target region, did not examine supply chain barriers, or were published prior to 2014.

Study Selection

The study selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a rigorous and unbiased review (Page et al., 2021). The selection process was conducted in three stages. Initially, two independent reviewers screened the titles and abstracts of all identified sources to determine their relevance based on the inclusion criteria. Any discrepancies in study selection were resolved through discussion, and a third reviewer was consulted when necessary to reach a consensus. Following the initial screening, a full-text review of potentially relevant sources was conducted. Two independent reviewers assessed these sources to confirm eligibility and ensure that they met the inclusion criteria. Any disagreements were discussed and resolved, with a third reviewer available to adjudicate when consensus could not be reached.

In the final stage, a comprehensive inclusion check was conducted to ensure that all selected sources aligned with the review's scope. This involved a thorough review of both reviewers' data extraction forms and the full-text articles, with additional input from a third reviewer when

needed. This multi-step approach strengthened the reliability of the study selection process, ensuring that only the most relevant sources were included in the review (Appendix, Figure A1).

Data Management, Reviewing, and Appraisal

The selected sources were systematically organized and categorized for analysis and synthesis. Each source was cataloged according to predefined criteria to facilitate structured data extraction across production, aggregation, distribution, and retail domains. To enhance reliability, two independent reviewers conducted data extraction. Discrepancies were resolved through consensus discussion; when agreement could not be reached, a third reviewer adjudicated.

To assess the credibility of grey literature sources, an adapted AACODS framework (Authority, Accuracy, Coverage, Objectivity, Date, and Significance) was applied (Tyndall, 2010). Each grey literature source was independently appraised across all six domains. Rather than applying a numeric scoring system, reviewers assessed whether sources met minimum credibility expectations in authority (recognized institutional or organizational authorship), transparency of data or methodology, relevance to the regional food supply chain context, and absence of overt commercial bias. Sources lacking identifiable authorship, methodological transparency, or clear relevance, as well as sources showing overt commercial bias, were excluded. Disagreements in appraisal were resolved through discussion and, when necessary, third-reviewer adjudication. No source meeting relevance criteria was excluded solely due to minor methodological limitations; however, quality concerns were documented and considered during synthesis.

Information Extracted

For each included source, reviewers extracted the source title, publishing or commissioning organization, authors, publication year, geographic scope, food system focus, study objectives, and key findings relevant to supply chain barriers. Extracted information was used to identify recurring vulnerabilities (e.g., water scarcity, climate and labor instability, aggregation and cold-storage gaps, transportation bottlenecks, retail-access inequities, and cross-border regulatory delays affecting food production) in the southern border counties of Texas and New Mexico, as well as in aggregation, distribution, retail access, and cross-border coordination. Following data extraction, two reviewers conducted an inductive thematic synthesis using a structured coding protocol rather than formal qualitative analysis software. Barrier categories were allowed to emerge from the extracted findings rather than being applied from a predetermined framework. Reviewers independently coded each source by identifying recurring barriers and assigning provisional codes with operational definitions and supporting examples. Codes were then compared across sources to identify patterns of convergence, divergence, and overlap.

Through iterative consensus discussion, related codes were clustered into higher-order themes representing systemic challenges, infrastructure and cross-border constraints, and sector-specific interactions across the regional food supply chain. Themes were finalized when no additional higher-order barrier categories emerged from the included sources and when each theme could be supported by evidence from more than one source type, where available. Throughout this process, coding decisions and evolving theme definitions were documented in a shared working file to support consistency and provide an informal audit trail. The final thematic structure, including theme labels, definitions, and supporting evidence, was reviewed by the author team before being incorporated into the Results and Discussion section.

Results and Discussion

This scoping review synthesized findings from nine peer-reviewed and grey literature sources published between 2014 and 2024. As shown in the Appendix, Table A1, the majority of the grey literature sources met high standards for authority, objectivity, and regional relevance, although most relied on qualitative or stakeholder-driven methods. This pattern reflects regional evidence grounded in applied planning and community engagement rather than quantitative evaluation studies. Infrastructure and aggregation gaps were identified in at least five of the nine sources (Barber & Stone,

2023; Ferrini, 2021; Frost & New, 2023; Nelson & Kraenzel, 2017; Rasmussen, 2019), suggesting structural entrenchment. By contrast, cross-border regulatory volatility was emphasized in only two sources (Barber & Stone, 2023; Ferrini, 2021), suggesting this constraint may be commodity- or pathway-specific rather than universal. These patterns of convergence and divergence are discussed in the sections that follow.

Comparative analysis of the nine sources (Appendix Table A2) reveals notable convergence across domains. Infrastructure and aggregation gaps were identified in at least five reports (Barber & Stone, 2023; Ferrini, 2021; Frost & New, 2023; Nelson & Kraenzel, 2017; Rasmussen, 2019), consistently highlighting limited cold storage, processing capacity, and transportation coordination as barriers to market access. Environmental and water governance constraints have been emphasized in Rader et al. (2016), Raj and Raja (2018), and Orozco Santos (2022), suggesting that irrigation inequities, declining flows of the Rio Grande, and drought-related yield instability function as persistent structural constraints on production. Retail access inequities, particularly in colonias, have been documented by Barber and Stone (2023), Ferrini (2021), and Orozco Santos (2022), linking infrastructure deficits and transportation gaps to limited product diversity at the community level.

Divergence across sources was most apparent in the treatment of cross-border dynamics. While Barber and Stone (2023) and Ferrini (2021) explicitly identified inspection delays and regulatory volatility at ports of entry as supply chain stressors, other reports focused primarily on intra-state infrastructure and governance challenges. This variation suggests that cross-border dependencies may disproportionately affect specific commodities or logistics pathways rather than uniformly shaping all sectors.

During iterative coding, individual barriers identified within each source were first categorized by supply chain segment (production, aggregation, distribution, retail) and by type of constraint (environmental, infrastructural, governance, labor-related). Cross-source comparison of these coded categories revealed recurring structural clusters, which were then consolidated into three higher-order themes. Synthesizing these convergent and divergent patterns, three overarching themes emerged: (1) systemic environmental and governance constraints; (2) infrastructure and cross-border capacity limitations; and (3) sector-specific barriers that interact across production, aggregation, distribution, and retail. Notably, environmental water constraints and infrastructure gaps for aggregation appear consistently across multiple reports, suggesting structural entrenchment, whereas trade volatility and localized irrigation conflicts exhibit greater contextual variability.

Systemic Challenges Across Regional Food Supply Chains

Environmental pressures consistently emerged as some of the most significant barriers to food system stability. In the work of Rader et al. (2016), producers reported operational downsizing, reduced cultivated acreage, and shifting planting cycles in response to chronic drought, aquifer depletion, and declining Rio Grande flows. Similarly, Orozco Santos (2022) documents soil degradation, declining yields, and increased pest pressure, particularly for high-value crops such as chili peppers, pecans, and onions. These findings indicate that small and medium-sized producers, particularly those without access to adaptive technologies or capital, face disproportionate risks under intensifying climate stress.

Water governance conflicts further exacerbate these environmental barriers. Raj and Raja (2018) highlight irrigation inequities and urban land-use competition in Doña Ana County, where smaller producers reported restricted access to critical water resources. These findings align with a report by New Mexico First (2020) that emphasizes that fragmented policy frameworks and insufficient cross-sector coordination limit regional capacity to respond effectively to water scarcity and other systemic stressors.

Labor instability compounds these production-level vulnerabilities. According to Barber and Stone (2023), the region remains heavily dependent on migrant and seasonal agricultural workers, exposing production systems to disruptions from immigration enforcement, inconsistent visa policies, and

limited workforce protections. Seasonal workforce shortages, particularly when involving crops that require intensive manual labor, exacerbate productivity declines associated with environmental stressors. Together, these findings demonstrate how environmental, governance, and labor pressures interact to reduce regional agricultural productivity, increase operational costs, and drive reliance on external suppliers, setting the stage for downstream disruptions across aggregation, distribution, and retail sectors.

The nine sources consistently characterize the economic consequences of structural barriers in qualitative and directional terms, though few provide precise monetary estimates of their impacts. Nelson and Kraenzel (2017) noted that the absence of local aggregation and processing infrastructure compels producers to seek distant facilities, with associated transportation costs identified as a key barrier to market participation for smaller operations. Rasmussen (2019) reported that the lack of regional hub access limits producers' ability to meet institutional buyer volume thresholds, reducing their competitiveness in school, hospital, and other procurement markets. Barber and Stone (2023) documented that transportation gaps and distributor fragmentation result in higher consumer prices and reduced product diversity in colonia communities, particularly for perishable goods. Ferrini (2021) characterized cross-border inspection delays as contributors to spoilage losses and elevated logistics costs, though precise estimates were not reported.

Collectively, the reviewed literature describes a pattern in which structural barriers increase costs and reduce revenues across multiple supply chain actors (producers, distributors, and consumers), but the evidence base does not yet support precise cross-sector monetary quantification. Future research should prioritize empirical cost estimation to strengthen the economic case for targeted infrastructure and governance investments. Drawing on available evidence, several proxy indicators help characterize the scale of economic burden. Transportation distance to the nearest aggregation or cold storage facility functions as a proxy for disproportionate freight cost burden: Rasmussen (2019) documents that frontier producers in New Mexico often lack access to local hubs, implying extended haul distances that inflate per-unit logistics costs and reduce competitiveness for small-scale operations. The frequency and duration of cross-border inspection holds, identified by Ferrini (2021) as a recurring stressor, serves as a proxy for spoilage-related revenue loss, particularly for perishables such as chili peppers, pecans, and leafy greens with narrow post-harvest windows. Exclusion from institutional procurement markets due to unmet volume thresholds, documented by Rasmussen (2019) and Nelson and Kraenzel (2017), represents a proxy for foregone revenue: institutional buyers (schools, hospitals, and similar entities) offer stable, premium-priced procurement channels that remain inaccessible to producers lacking aggregation support. Collectively, these proxies suggest that economic losses are distributed across all supply chain tiers and are disproportionately borne by the smallest actors, reinforcing the case for targeted infrastructure and governance investment.

Infrastructure Gaps and Cross-Border Barriers

Infrastructure deficits were widely identified as persistent, structural challenges across the food supply chain, particularly in terms of aggregation capacity, cold storage, and processing facilities. Rasmussen (2019) and Nelson and Kraenzel (2017) found that the absence of regional hubs forces producers to transport products long distances for storage and consolidation, inflating operational costs and limiting participation in institutional procurement programs like schools and hospitals. Without localized facilities, smaller producers lack equitable access to competitive markets and face a heightened risk of spoilage. Frost and New (2023) add further evidence of structural aggregation gaps, noting that rural and underserved communities across New Mexico and western Texas face widespread shortages of cold storage capacity, processing facilities, and shared-use infrastructure. Although the Resilient Food Systems Infrastructure Program discussed by Frost and New highlights plans to invest in infrastructure development, the baseline findings underscore the depth of unmet aggregation and processing needs that directly affect the viability of smaller producers.

Distribution systems face similar constraints.

Barber and Stone (2023) and Ferrini (2021) document the problems of insufficient transportation fleets, poorly maintained rural roads, and fragmented logistics systems, which reduce reliability and increase the costs of product movement. These transportation gaps disproportionately affect colonias and other rural areas, where distance from supply hubs exacerbates delays and worsens retail inequities. Ferrini (2021) further highlights inefficiencies arising from limited coordination among distributors, leading to underutilization of existing transportation capacity.

Cross-border dependencies introduce another layer of complexity unique to the Texas–New Mexico region. Barber and Stone (2023) and Ferrini (2021) report that extended inspection delays, shifting port regulations, and inconsistent trade policies significantly slow the movement of products at U.S.–Mexico crossings. These delays often lead to spoilage of perishable goods and elevate consumer costs, while policy uncertainty discourages investment in regional logistics capacity. Because the region's food systems rely heavily on binational flows of inputs and products, disruptions at the border amplify the effects of upstream environmental constraints and local infrastructure deficits.

Perishable, high-value commodities, such as fresh chili peppers, pecans, onions, and leafy greens, are disproportionately vulnerable to cross-border inspection delays because of their narrow spoilage windows. Small and medium-scale producers who lack refrigerated transport capacity or financial reserves to absorb holding costs face the greatest risk exposure. Distributors operating time-sensitive logistics routes and small retailers in colonias who depend on regular restocking of perishables are similarly affected. These actors typically lack the contractual leverage and infrastructure redundancy of larger supply chain operators, making them structurally less able to absorb the cost and spoilage risks associated with regulatory volatility at ports of entry. At the system level, these cross-border dynamics generate a compounding fragility that extends well beyond individual shipment delays. When inspection disruptions coincide with upstream production shortfalls or seasonal labor constraints, the resulting compounded supply interruptions propagate downstream through aggregation bottlenecks and distribution gaps, ultimately inflating wholesale and retail prices in colonias and reducing the variety and availability of fresh foods reaching the most vulnerable communities. Repeated exposure to this volatility may also produce longer-term structural effects: smaller distributors operating thin margins may exit time-sensitive perishable routes altogether, reducing the overall number of actors willing to service border-adjacent markets. This market withdrawal dynamic concentrates distribution capacity in larger, better-capitalized operators and reinforces structural inequities in retail access. Taken together, these system-level consequences position cross-border regulatory governance not as a peripheral logistical concern but as a structural determinant of regional food system resilience, one that interacts with and amplifies the effects of environmental, infrastructure, and labor constraints across all supply chain sectors.

Sector-Specific Barriers and Interactions

Findings across the sources highlight how challenges in production, aggregation, distribution, and retail systems are deeply interconnected, producing cascading effects throughout the regional food supply chain. Production barriers are consistently documented in Rader et al. (2016), Orozco Santos (2022), and Raj and Raja (2018), which collectively report that prolonged drought, declining Rio Grande flows, soil degradation, rising input costs, and unstable labor supply constrain yields and increase production volatility—particularly for irrigated specialty crops such as chili peppers and pecans.

A representative cascade emerges when these upstream stressors are traced across sectors. Reduced yields and irrigation instability limit consistent product volumes, making it difficult for smaller producers to meet aggregation thresholds required by regional hubs (Frost & New, 2023; Rasmussen, 2019). In turn, limited aggregation capacity and reliance on distant cold storage facilities increase transportation distances and fuel costs (Ferrini, 2021; Nelson & Kraenzel, 2017). These distribution inefficiencies contribute to higher wholesale prices and reduced product diversity

reaching rural colonias, where small retailers already operate with constrained refrigeration capacity (Barber & Stone, 2023; Orozco Santos, 2022). The result is not simply a production shortfall but a downstream amplification of cost and access inequities. This pattern illustrates how environmental and governance constraints at the production level propagate through infrastructure and logistics bottlenecks, ultimately shaping retail affordability and food access outcomes.

Aggregation bottlenecks, described by Frost and New (2023), Nelson and Kraenzel (2017), and Rasmussen (2019) stem from limited cold storage, processing facilities, and consolidation hubs. Without accessible infrastructure, producers incur higher transportation expenses and face barriers to entering competitive institutional and retail markets. Distribution constraints identified by Ferrini (2021) and Barber and Stone (2023) include limited trucking fleets, degraded road networks, rising fuel costs, and coordination inefficiencies. These gaps directly contribute to higher consumer prices and limit product diversity, particularly in remote communities.

Retail inequities are highlighted by Ferrini (2021) and Orozco Santos (2022), which document that many rural colonias rely on small convenience stores that lack refrigeration capacity, thereby restricting access to fresh, perishable foods. Ferrini (2021) further notes that structural affordability constraints limit households' ability to consistently purchase higher-cost, perishable products, even when there is clear interest in accessing nutritious foods. Because fresh produce and refrigerated items often carry higher price points and greater spoilage risk, retailers in low-income areas may limit inventory expansion due to thin profit margins and uncertain turnover. This dynamic reflects cost and infrastructure barriers, rather than a lack of consumer preference for healthier foods.

Across these sectors, findings reveal that barriers are mutually reinforcing. For example, production declines linked to drought and irrigation conflicts (Rader et al., 2016; Raj & Raja, 2018) increase reliance on distant aggregation facilities (Frost & New, 2023; Rasmussen, 2019), raising transportation costs and resulting in higher retail prices and reduced product diversity (Barber & Stone, 2023; Ferrini, 2021). These cascading impacts demonstrate that addressing barriers within a single sector is insufficient; the evidence suggests the need for integrated strategies that span production, aggregation, distribution, and retail systems.

Strengths and Limitations

A major strength of this review is its integration of grey literature, which enabled including localized perspectives from community needs assessments, producer-focused surveys, and regional policy analyses. Applying the AACODS framework ensured the inclusion of good-to-high-quality grey literature and enhanced the relevance of findings for underserved regions in Texas and New Mexico.

However, several limitations should be noted. First, reliance on grey literature and regional reports may have introduced selection bias, as sources that were publicly available, easily retrievable, or produced by more visible organizations may have been more likely to be included than unpublished, internal, or less accessible local documents. As a result, some perspectives, particularly from smaller producers, informal food system actors, or under-resourced community organizations, may be underrepresented. Second, variability in methodological rigor and considerable heterogeneity in source type (including differences in study design, geographic coverage, data collection methods, and reporting standards) limited opportunities for direct comparative quantitative analysis and may have affected the comparability of findings. Third, the geographic scope, southern Texas and the border counties of New Mexico, constrains generalizability to other regions. Finally, many of the included sources were descriptive rather than evaluative, leaving critical gaps in the evidence on the effectiveness of specific interventions to mitigate barriers. Future research should prioritize empirical evaluations of infrastructure investments, cross-border coordination strategies, and climate-adaptive agricultural practices in order to inform targeted policy and regional planning.

This review highlights opportunities to address structural challenges in the food supply chain through coordinated regional planning and investment. The analysis was initially undertaken during planning for the RGC-RFBC, a USDA-funded ini-

tiative. Although the program is no longer active, the structural vulnerabilities identified in this review (particularly those related to water governance constraints, gaps in aggregation infrastructure, volatility in cross-border inspections, and labor instability) remain salient for regional stakeholders. The findings suggest that infrastructure expansion alone is unlikely to resolve supply chain fragility without concurrent attention to environmental governance, workforce stabilization, and binational coordination mechanisms. Addressing these interdependent constraints will require sustained cross-sector collaboration among producers, distributors, policymakers, and community organizations, irrespective of specific federal programmatic vehicles.

Conclusion

Across the nine included sources, we identified a network of systemic barriers that span production, aggregation, distribution, and retail systems, shaping food availability, affordability, and access in the region. At the production level, persistent drought, aquifer depletion, extreme heat, and conflicts over water governance reduce yields, increase input costs, and create a reliance on external suppliers. In aggregate, the lack of sufficient cold storage, processing capacity, and regional hubs forces many producers to rely on distant facilities, thereby increasing transportation expenses and limiting their participation in institutional markets. Within distribution networks, challenges include inadequate fleets, poorly maintained rural roads, and cross-border dependencies, which can lead to inspection delays and shifting regulatory requirements, thereby elevating spoilage risk and increasing consumer costs. Finally, retail access inequities are especially pronounced in rural colonias, where limited refrigeration capacity, constrained purchasing power, and a lack of nearby outlets result in reduced product diversity and limited availability of nutritious foods.

Findings across these sectors underscore that barriers do not operate in isolation. Instead, upstream production shortfalls cascade into aggregation bottlenecks, distribution inefficiencies, and restricted retail availability, amplifying inequities for underserved communities. Addressing these interconnected challenges will require coordinated regional strategies that integrate infrastructure investments, aligned water governance, workforce stabilization, and cross-border logistics coordination. While initiatives such as the RGC-RFBC were designed to facilitate stakeholder engagement and infrastructure planning, policy volatility and funding shifts underscore the need for more durable coordination mechanisms. These mechanisms may include state-level infrastructure consortia, producer-led aggregation cooperatives, regional cold-chain partnerships, formalized binational inspection coordination agreements, and locally anchored public–community investment models that reduce dependence on single federal funding streams.

Although the evidence base does not clearly identify a single superior model across all regional food systems, prior research and practice-oriented literature generally support multi-stakeholder governance structures with dedicated coordination capacity as the most promising mechanism for addressing fragmented supply chains. For policymakers, this suggests that the most actionable approach may be a regional food systems consortium or coordinating body that brings together producers, distributors, public agencies, community organizations, and cross-border regulatory partners. Such a mechanism could align infrastructure investments, aggregation capacity, cold-chain logistics, inspection coordination, and workforce strategies under a shared regional plan. Compared with isolated investments in individual facilities or programs, this type of coordinated governance model may be better positioned to sustain supply chain resilience amid shifting policy environments and changing federal funding priorities.

To translate these findings into actionable guidance, we propose several concrete policies and planning priorities. First, state and regional agencies should prioritize investment in shared cold-chain and aggregation infrastructure in underserved rural areas, with particular attention to colonia communities that currently rely on small-format outlets lacking refrigeration. Second, binational task forces involving U.S. and Mexican customs and agriculture agencies should explore streamlined, commodity-specific inspection protocols to

reduce the risk of perishable spoilage at ports of entry. Third, workforce-stabilization policies, including expanded agricultural visa programs and occupational protections for seasonal workers, should be pursued in tandem with infrastructure investments, as labor instability directly amplifies the downstream effects of environmental and logistics constraints. Fourth, water governance reform at the regional and interstate level should integrate agricultural access priorities, ensuring that small and mid-scale producers can sustain irrigated production under worsening climate conditions. These priorities are sequentially interdependent: infrastructure investments will yield limited returns without concurrent attention to governance, labor, and environmental constraints.

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Appendix Table A1. Appraisal of Included Grey Literature Sources Using the AACODS (Authority, Accuracy, Coverage, Objectivity, Date, and Significance) Framework

#	Source Title	Authority	Methodological Rigor/Accuracy	Coverage & Relevance	Objectivity	Date	Overall Appraisal
1	**Texas Food Access Study**	Strong (UT-RGV)	Moderate: Synthesizes community input, administrative data	High: Targets underserved areas with food access barriers	High: Developed by academic and public-sector collaborators; no commercial bias; aimed at informing city-level policy	2023	**High**
2	**Resilience in NM Agriculture**	Strong (New Mexico First & NMSU)	Moderate: Qualitative, stakeholder-driven	High: Focuses on resilience in New Mexico's agricultural systems	High: Produced through public engagement and supported by a university; intended to inform inclusive policy	2016	**High (despite age)**
3	**Food Security Task Force Report**	Strong (City of El Paso)	Moderate: Policy recommendations based on local agency input	High: Centers on food infrastructure and equity	High: Commissioned by a local government to support regional food policy and climate adaptation; objective in focus	2021	**High**
4	**Resilient Food Systems Infrastructure (RFSI) Program**	Moderate (NM Dept. of Agriculture)	Moderate: Stakeholder survey; responses used for policy development	Moderate: Targets USDA and state-level funding priorities	Moderate: Developed as part of a USDA initiative; aligned with public funding goals; possible internal prioritization, but no private-sector bias	2023	**Moderate to High**
5	**Health: Body, Mind, and Spirit Town Hall**	Strong (New Mexico First)	Moderate: Qualitative insights from town hall dialogues	Moderate: Includes health, wellness, and food access concerns	High: Driven by community voices through participatory process; no commercial agenda; seeks broad health and policy equity	2020	**Moderate**
6	**Value-Added Market Feasibility Study**	Strong (La Semilla Food Center)	High: Data-informed feasibility analysis with economic modeling	High: Clear relevance to food system economics and producer resilience	High: Conducted by a nonprofit with food justice mission; objective in evaluating viability without private gain	2017	**High**
7	**Snapshots of Resilience**	Strong (La Semilla Food Center)	Moderate: Narrative, community-based case study approach	Moderate: Offers qualitative data on resilience at household/farm level	High: Community storytelling without policy lobbying or commercial angle; centered on resilience and justice	2022	**Moderate to High**
8	**Agrarian Values and Urban Futures**	Moderate (Growing Food Connections)	Moderate: Policy analysis grounded in land-use planning	Moderate: Focuses on governance and agricultural futures	High: Aimed at informing local governments; developed by university and nonprofit partnership; no corporate affiliations	2018	**Moderate**
9	**Feasibility of a Regional Food Hub for Southwest NM**	Strong (NCFC)	High: Combines producer interviews and buyer surveys	High: Highly relevant to food supply infrastructure and procurement	High: Developed by a nonprofit serving rural communities; supports economic development without commercial promotion	2019	**High (especially for infrastructure insight)**

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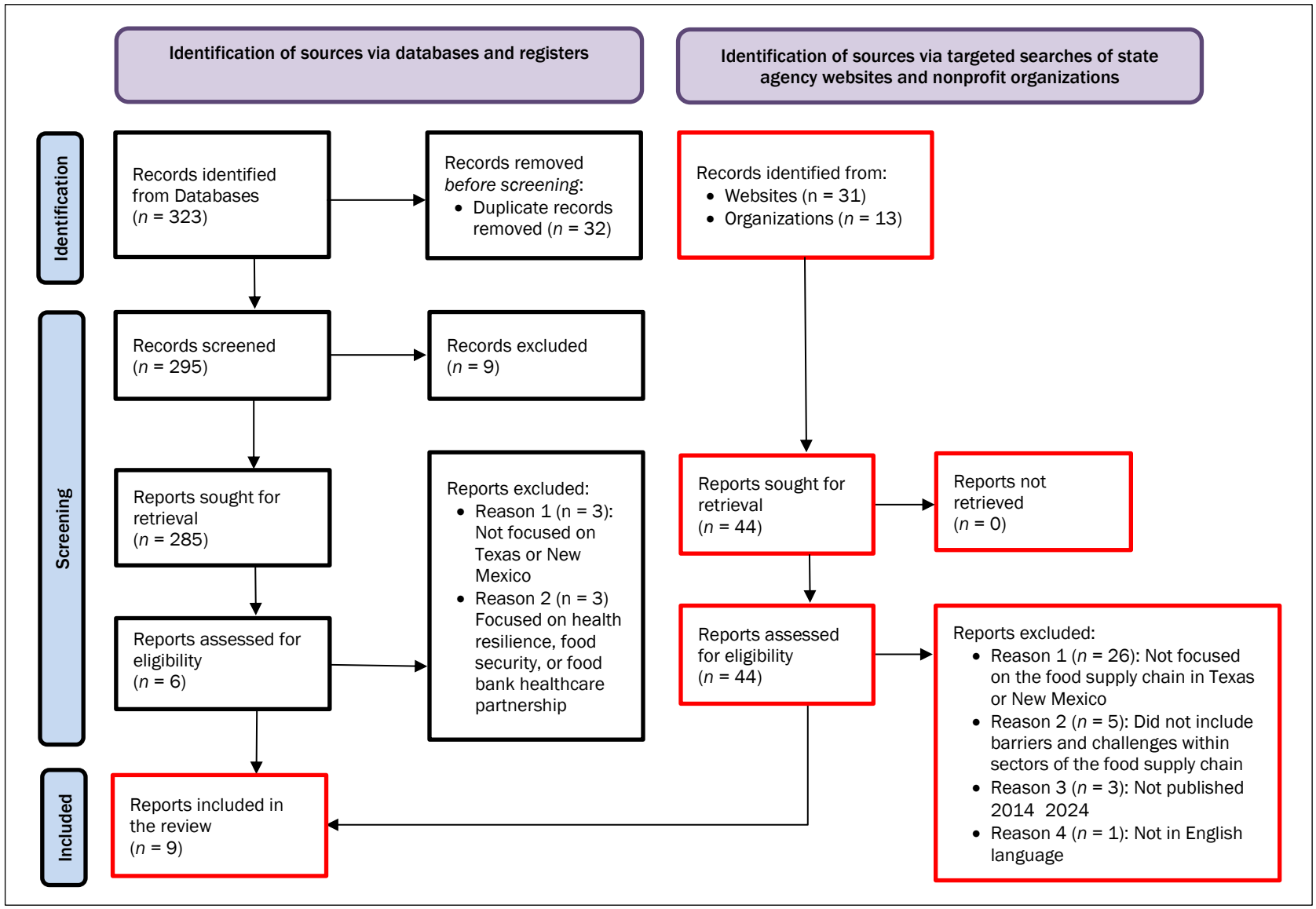
Appendix Table A2. Description, Relevance, and Conclusions of Articles and Reports Included in the Review

#	Title	Source	Authors (Year)	Scope & Focus	Key Findings	Relevance to Food System	Conclusions
1	**Texas Food Access Study**	UT Rio Grande Valley	Barber & Stone, 2023	Examines barriers to food access and potential solutions	Identifies barriers to food access (e.g., grocery store distribution, economic factors) and strategies to address them	Informs targeted interventions for underserved communities	Enhanced coordinated efforts and collaboration among food supply chain sectors can maximize limited resources to better adapt to climate, supply, and distribution-related challenges
2	**Resilience in NM Agriculture**	New Mexico First & NMSU	Rader et al., 2016	Stakeholder-driven assessment of NM's agricultural resilience	Calls for a balance between export-oriented agriculture and local food networks; emphasizes multi-stakeholder collaboration	Identifies economic and environmental factors affecting agricultural resilience	Highlights the need for collaboration and strategic planning among diverse stakeholders to address challenges in New Mexico's agricultural industry, ultimately aiming for a resilient, cooperative, and economically viable food system
3	**Food Security Task Force Report Recommendations**	City of El Paso	Ferrini, 2021	Policy recommendations for food security	Proposes solutions for food access, funding allocation, and infrastructure improvements	Offers policy solutions for food security and local food infrastructure	To ensure food security and improve food access in El Paso County, efforts must focus on establishing a comprehensive food system, integrating food security into climate planning, and implementing food waste policies.
4	**Resilient Food Systems Infrastructure Program (RFSI)**	New Mexico Department of Agriculture	Frost & New, 2023	Stakeholder survey on food system resilience initiatives	Highlights priority needs for technical assistance, market access, and USDA funding opportunities	Identifies investment opportunities to strengthen food infrastructure	Insights from stakeholder survey results were used to guide the finalization of state funding priorities that were also included in the RFA.
5	**Health: Body, Mind, and Spirit Town Hall**	New Mexico First	New Mexico First, 2020	Statewide discussions on public health and policy needs	Informs state policy through community-driven insights, including food access considerations	Provides community-driven perspectives on food system challenges	Investment in policies and strategies that help local food systems flourish and strengthen resilient local agriculture is needed.
6	**Value-Added Market Feasibility Study for NM Products**	La Semilla Food Center	Nelson & Kraenzel, 2017	Examines potential for developing value-added agricultural products	Identifies top products for local processing and economic viability	Highlights market opportunities for local farmers and processors	Findings recommend developing a detailed business strategy that highlights methods which will strengthen the organization's competitive advantage.
7	**Snapshots of Resilience: Tending Land & Food Traditions**	La Semilla Food Center	Orozco Santos, 2022	Community narratives on food access and cultural food practices	Documents barriers and adaptive strategies in food production and household food security pre- and post-COVID-19	Provides qualitative insights into resilience strategies	Embracing resilience is essential to adapt and innovate for future generations.

8	**Agrarian Values and Urban Futures**	Exploring Stories of Opportunity	Raj & Raja, 2018	Policy and food system challenges	Provides policy insights for local government on agriculture and food security	Explores land-use policies and governance challenges affecting food systems	Improved public policy engagement is essential to support agricultural innovation, farmland protection, community food assessments, and stable funding for grassroots food system initiatives.
9	**Feasibility of a Regional Food Hub for Southwest NM**	National Center for Frontier Communities	Rasmussen, 2019	Assessment of farmer and buyer interest in a regional food hub	Evaluates local farmers' capacity and institutional buyer demand for a regional hub	Supports local procurement and supply chain infrastructure	A regional food hub would boost local farmers' earnings, expand market access, improve healthy food availability in low-access areas, and strengthen the regional economy.

Appendix Figure A1. PRISMA Flowchart with Reasons for Exclusion



Adapted from Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA 2020 Statement (Page et al., 2021).

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Minding the implementation gap: A mixed-method study of producer capabilities and institutional pressures in U.S. Midwest values-based food procurement

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Abstract

Values-based institutional food procurement (VBIFP) aligns institutional purchasing with shared social values, including sustainability, nutrition, and equitable supplier inclusion. Using a mixed-methods approach combining a survey of 189 producers with stakeholder interviews, this study examines producer readiness, participation, and systemic barriers to VBIFP adoption in the U.S. Midwest region, with particular attention on small-scale and ethnic-minority producers. Despite growing adoption of values-based procurement among public institutions, many producers whose operations most closely embody these principles—small-scale, sustainability-oriented, and ethnic-minority suppliers—remain largely excluded from institutional markets. Minimum volume thresholds and certification mandates emerged as the most

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Conflict of Interest Declaration

The authors declare that there are no conflicts of interest related to this research. All authors have reviewed and approved this statement.

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significant barriers to participation. While small-scale and ethnic-minority producers were more likely to engage in values-based practices like cultivating culturally relevant crops and implementing sustainable practices, entrenched procurement norms centered on cost minimization continue to limit their market access. Technological limitations and the lack of supplier aggregation further restrict VBIFP adoption. Integrating resource-based and institutional theories, this study provides empirical evidence showing how producer resource constraints interact with *coercive* procurement rules and *normative* practices to exclude values-aligned suppliers. Actionable policy and procurement recommendations—including values-aligned scoring, flexible contracting models, and cooperative aggregation partnerships—can expand equitable participation in institutional food markets.

Keywords
values-based procurement, small-scale producers, sustainable supply chain, institutional food systems

Introduction

Institutional food procurement (IFP), which encompasses public agencies, private organizations, hospitals, universities, and other large-scale buyers, represents enormous purchasing power in the U.S. (Jones & Toossi, 2024). This purchasing power has prompted policymakers to use public procurement to promote local economic development, social equity, and environmental sustainability goals (Baek & Radziwon, 2023; Salvatore et al., 2021; Sonnino, 2009; Tregear et al., 2022). IFP systems must feed large congregate populations, requiring large volumes of standardized products at affordable prices (Carlisle et al., 2019; Izumi et al., 2010; Klein, 2015). Institutionalization forces have shaped procurement systems to meet these goals (DiMaggio & Powell, 1983), but have also led to industry concentration and created supply chain vulnerabilities. During COVID-19, for example, institutional food supply chains were disrupted due to facility and border closures. By contrast, diverse local supplier networks demonstrated more resilience and adaptability, underscoring the need for more inclusive and decentralized procurement systems (Hendrickson, 2020; Thilmany et al., 2021).

Values-based institutional food procurement (VBIFP) emerged as a framework to harness the transformative potential of IFP and promote social values. VBIFP integrates social, economic, and environmental objectives into purchasing decisions while maintaining traditional metrics like cost and volume (Berti & Mulligan, 2016; Campbell, 2023; Food and Agriculture Organization of the United Nations [FAO], n.d.; Salvatore et al., 2021). The Good Food Purchasing Program (GFPP) is the most popular VBIFP program in the U.S., adopted by 30 cities and counties (Center for Good Food Purchasing [CFGFP], 2025; Daniels & Delwiche, 2022). Between 2011 and 2017, Los Angeles institutions participating in GFPP reported over US$56 million in local economic benefits and significant greenhouse gas reductions (Daniels & Delwiche, 2022).

The existing literature documents VBIFP program structures, and identifies participation barriers for local producers revealing a persistent implementation gap. Despite the growing adoption of VBIFP, producers whose operations most closely embody values-based principles—small-scale, sustainability-oriented, and local suppliers—remain largely excluded from the institutional markets, limiting the realization of VBIFP's intended outcomes (CFGFP, 2023; DiBella et al., 2023; Lehtinen, 2012; Michel-Villarreal, 2022). The mechanisms shaping VBIFP implementation (producer readiness and institutional receptivity) are not unique to the U.S. Similar tensions exist internationally. For example, in the European Union's Farm-to-Fork program, policymakers seek to promote more sustainable, transparent, and community-focused food systems (Elshaer et al., 2023). Nonetheless, small producers face comparable barriers related to certification costs, aggregation challenges, and minimum volume thresholds. These requirements limit participation in institutional procurement, despite producers' alignment with sustainability and nutrition goals (Cimino et al., 2024; Jackson et al., 2024; Kumar et al., 2025; Miranda, 2018; Peterson et al., 2022; Walker & Preuss, 2008).

Although, research recognizes this implementation gap, important empirical and theoretical limitations remain. First, there is limited empirical evidence quantifying how the adoption of values-

based practices varies across producer size and demographic characteristics (Augustine, 2019; Love et al., 2025). Second, few studies systematically examine how institutional procurement mechanisms translate into concrete access barriers (Daniels & Delwiche, 2022). Finally, existing research rarely integrates institutional theory and resource-based theory to explain how structural pressures and producer capabilities interact to shape VBIFP outcomes (Campbell, 2023; Federal Good Food Purchasing Coalition [FGFPC], 2023; Smith et al., 2016; Tregear et al., 2022). Without a clearer understanding of these dynamics, policymakers lack the evidence needed to design targeted interventions that bridge the gap between VBIFP's aspiration and its practical implementation.

This study addresses these gaps in the Metro Chicago region, using a mixed-methods design that combines a survey of 189 producers with stakeholder interviews. Specifically, it examines (1) how the adoption of VBIFP practices varies by producer demographics (RQ1); (2) what systemic barriers limit small-scale and ethnic-minority producers' access to institutional markets (RQ2); and (3) what buyer-side constraints impede VBIFP implementation (RQ3). By providing empirical evidence on both producer and institutional dynamics, this research offers insights that can help policymakers develop targeted interventions to meet VBIFP's aspirations while expanding equitable participation in institutional food procurement.

Literature Review

This literature review introduces VBIFP and establishes the theoretical foundation for understanding VBIFP implementation dynamics.

Values-Based Institutional Food Procurement (VBIFP)

VBIFP represents a shift from traditional high-volume and efficiency-oriented procurement models to collaborative, ethical, and relational sourcing by public and private institutions. Traditional food procurement models rely on supply chains characterized by cost minimization, efficiency, and length (Peterson et al., 2022; Stevenson & Pirog, 2008). VBIFP aligns with the logics for sustainable supply chains (SSC) and values-based supply chains (VBSC) (Campbell, 2023). While SSCs are focused on sustainability values and span many diverse industries, VBSCs focus on food systems, emphasize shared values and product differentiation, including farm identity (Lerman, 2012).

VBIFP applies SSC and VBSC principles to institutional contexts, where public and private buyers leverage purchasing power for broader policy objectives and sustainability goals (Berti & Mulligan, 2016; Campbell, 2023; Love et al., 2025). Initiatives such as the U.S.'s farm-to-school and farm-to-institution programs (Buckley et al., 2013; D. Conner et al., 2014; Harris et al., 2012; Izumi et al., 2010; Matts et al., 2016); Canada's Local Food Infrastructure Fund, the EU's Farm to Fork Strategy (Enthoven & Van den Broeck, 2021), and Copenhagen's Food Strategy reflect this approach (Cavallari et al., 2024). These efforts are reinforced by consumer-driven trends, such as the growth of farmers markets and community support agriculture (Brown & Miller, 2008; GFI, 2021; Hassoun et al., 2022; Martinez & Park, 2021; Woods et al., 2017).

Proponents argue that VBIFP offers significant benefits. Institutional markets offer farmers opportunities for larger demand, diversification, and stability, as well as increased market orientation, the development of new products, and processes including improved data management systems (Morley, 2021). Peterson et al. (2022) found that 81% of farmers participating in VBSCs gained "access to new or larger markets" (p. 394). For institutions and food management companies, sourcing from local suppliers strengthens local economies and reinforces mutual economic and social benefits (Goggins, 2018). Local food procurement programs contribute to nutrition-related outcomes, including healthier eating patterns (Matts et al., 2016; Soares et al., 2017), economic growth, creating a positive multiplier effect that extends beyond individual channel partners (Preuss, 2007; Tregear et al., 2022).

Institutional Forces Shaping Procurement Systems

Institutional theory describes how coercive, mimetic, and normative forces shape institutional contexts and organizations' and individuals' behav-

iors within those contexts (DiMaggio & Powell, 1983). In the procurement context, coercive forces operate through formal requirements, e.g., certifications, insurance and volume thresholds, favoring larger vendors with greater administrative and financial resources (Flynn & Davis, 2017; Loader, 2015; Nemec, 2024). Normative forces are evident in professional procurement standards that prioritize cost efficiency as the dominant evaluation criterion, encouraging what Izumi et al. (2010) term "cost-based contracting culture" that disadvantages small-scale producers due to economies of scale and their more labor-intensive production practices. Empirical evidence supports this assertion: Tikkanen and Caleva (2011) found that cost remained the dominant award criterion and indeed served as the sole factor in municipal food tenders. Mimetic forces emerge through organizations' copying of successful peer behaviors, reinforcing standardized practices, structured contracting processes, and norms of large established supplier relationships (Campbell, 2023; Carlisle et al., 2019; Klein, 2015; Sonnino, 2009). The concentration of food-service management exemplifies this pattern: by 2015, 75% of U.S. distribution service contracts were held by two conglomerates with similar structures and service offerings (Federal Trade Commission [FTC], 2015).

Together, these institutional pressures systematically shape procurement market mechanisms, creating market access barriers for small and medium enterprises (SMEs), particularly through complex bidding procedures, and financial compliance and certification requirements (Enthoven & Van-den-Broeck, 2021; Flynn & Davis, 2017; Jablonski et al., 2016; Loader, 2015; Martinez et al., 2010; Nemec, 2024; Sonnino, 2009).

Transitioning to sustainable procurement practices like VBIFP necessitates a shift in institutional forces to alter buyers' and suppliers' behaviors (Goggins, 2018; Meehan & Bryde, 2011; Singh & Joshi, 2024). Research suggests that environmentally and socially responsible initiatives are more likely to be adopted when supported by regulatory frameworks, peer influence, and cultural expectations (Biggi et al., 2023; Glover et al., 2014; Saha et al., 2020). Alternatively, voluntary frameworks embraced by leading institutions can accelerate this shift (Grob & Benn, 2014). Institutional theory thus explains why VBIFP initiatives may fail despite good intentions: deeply ingrained norms and institutional structures resist change, favoring established ways of working and suppliers who can mimic incumbents.

Producer Resources and Capabilities

Strategic resources are unique assets that enable businesses to differentiate themselves and gain a competitive advantage in the market (Forsman, 2004). Similarly, organizations' unique capabilities shape their structures and processes, creating a competitive edge in the business environment (Grob & Benn, 2014). The resource-based theory literature describes how firms leverage their unique resources and capabilities to meet institutional and market demands. Firms that align their assets and organizational knowledge, including purchasing and supply functions, can improve economic performance and sustainability, which contributes to their competitive advantage (Kähkönen & Lintukangas, 2022)

Much of the literature on SMEs demonstrates that they lack many of the resources and capabilities of larger enterprises, which can limit their competitiveness when operating in markets where the latter is favored (Ashton et al., 2017; Hoekman & Taş, 2022; Lawrence et al., 2006; Miranda, 2018). In IFP, these include limited access to information, financial constraints, inconsistent product availability and quality, and limited technical capabilities. Small, local food producers also face external infrastructure constraints such as limited processing facilities, transportation, and storage limitations (Akenroye et al., 2020; Faulkner et al., 2023; Flynn & Davis, 2017; Galloway et al., 2023; Loader, 2015; Mahuwi & Israel, 2023; Martinez et al., 2010; Nemec, 2024).

Ethnic-minority producers encounter additional structural inequities. Historical exclusion from land ownership, financing, and federal agricultural support programs has disproportionally impacted them (Figueroa & Alkon, 2017; Carlisle et al., 2019). The 2017 Census of Agriculture indicated that only 1.4% of U.S. producers identified as Black, and that Black growers owned significantly smaller farms than white farmers (U.S. Department

of Agriculture, National Agricultural Statistics Service [USDA NASS], 2019). Gilbert-Overland (2024) studied how systemic racism perpetuates the barriers, including lack of access to land, capital, infrastructure, and knowledge, facing Black farmers and highlighted that VBIFP's potential is contingent upon addressing structural racism.

However, small food producers can use their unique firm attributes and market tactics to differentiate themselves. The local food movement leverages small producers' flexibility to produce a diversity of goods and close ties to local markets to their advantage (Belletti et al., 2020). Local food supply chains are seen as a more sustainable choice offering shorter deliveries, compact work-in-progress inventories, greater transparency, and more flexibility (Lehtinen, 2012). Similarly, Charters et al. (2017) emphasize the role of geographical and cultural resources as unique value propositions through *terroir* products: those with place-based characteristics that create market differentiation. Beyond geographical characteristics, terroir includes cultural heritage and local traditions, enabling producers to leverage their unique historical, cultural, and environmental contexts into their value proposition. Likewise, Nogueira et al. (2020) highlighted the ways urban food stakeholders leverage cultural capital to share knowledge, co-create processes and spark innovation.

Ethnic-minority farmers, including those who are Black, Indigenous, and People of Color (BIPOC), have demonstrated significant resilience through cultural preservation and collective agency (Nunoo, 2023). Many immigrant farmers from Latin America actively maintain traditional agricultural practices to sustain cultural identity and economic viability (Minkoff-Zern, 2019) favoring culturally significant crops and minimal synthetic inputs, thus aligning with VBIFP principles.

A Framework for Understanding the VBIFP Implementation Challenges

Understanding VBIFP implementation challenges requires integrating insights from institutional and resource-based theories (Mardani et al., 2020). Figure 1 illustrates how institutional pressures—coercive (mandated certifications), normative (price-focused contracts), and mimetic (emulating efficiency-focused procurement models)—influence market-shaping mechanisms such as eligibility rules, vendor approval processes, and contracting standards. These mechanisms, in turn, generate access frictions, including certification costs, minimum volume thresholds, and data or traceability requirements, which ultimately determine which

Figure 1. Research Questions on How Institutional Forces Shape Values-based Institutional Food Procurement

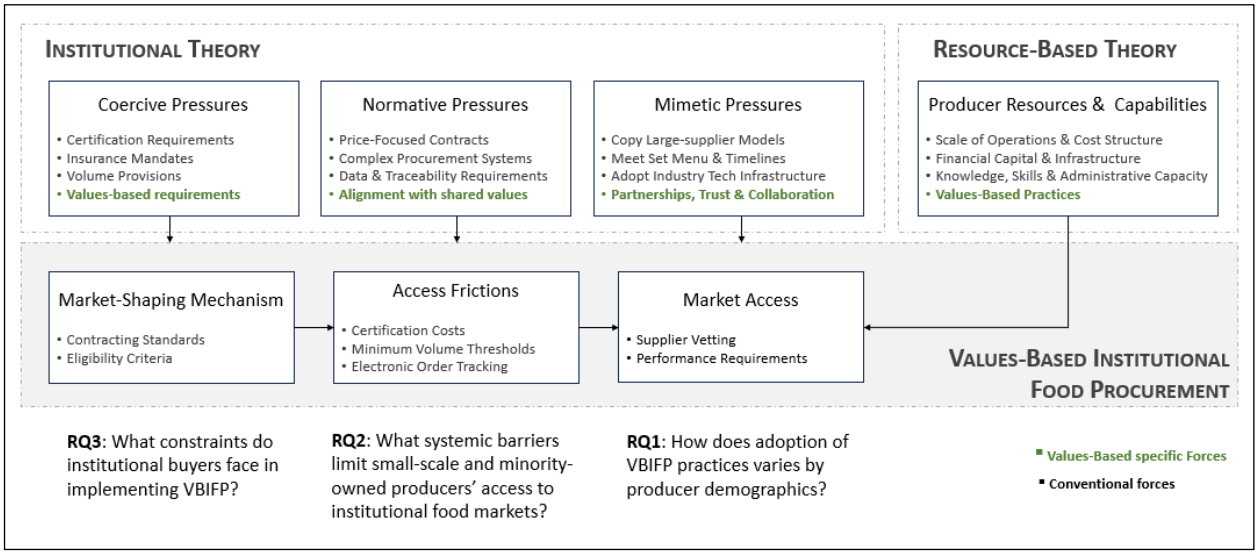

Figure created by the authors for this study.

producers can enter institutional supply chains. Producer entry and participation depend on the resources and capabilities they possess (scale, financial assets, and administrative capacity), as well as their alignment with institutional norms.

VBIFP introduces additional dynamics into this system. In particular, it incorporates norms around shared values such as sustainability, trust-building partnerships with SMEs outside of incumbent networks, and seeks to recognize suppliers who employ values-based production practices. The interaction of these institutional pressures, governance mechanisms, and producer capabilities shape VBIFP implementation and determine the extent to which institutional procurement can deliver its intended socio-economic and environmental benefits.

This framework builds on the conceptual framework proposed by Behravesh et al. (2022) on sustainable public-purchasing adoption, which focuses on organizational capacity, internal stakeholders, culture, and macroeconomic settings. Our study extend this work in several important ways. First, it integrates institutional and resource-based theories to trace the mechanisms linking institutional pressures to producer-level access frictions and market participation. Second, it incorporates both supplier and buyer perspectives through an empirically grounded mixed-methods approach that captures implementation dynamics across the procurement process. Third, it centers small-scale and BIPOC producers in the analysis, highlighting the historical and structural inequities that have shaped their uneven access to institutional markets.

Together, these contributions enable a system-level analysis of the VBIFP implementation gap (defined as the disconnect between values-based procurement goals and the extent to which institutions can purchase from values-aligned producers and the latter can sell to institutional markets) to generate actionable, policy-relevant insights grounded in implementation science. Specifically, this research examines (1) the adoption of values-aligned practices among suppliers, (2) the key barriers facing producers seeking to access institutional markets, and (3) the constraints institutional buyers face when implementing VBIFP.

Methodology

The study applied a sequential design (quantitative-qualitative) methodology to investigate VBIFP adoption and its challenges (Venkatesh et al., 2023). In the first phase, a quantitative survey explored regional producers' adoption of values-based practices and identified statistical patterns across distinct producers' groups and characteristics. These results informed the second, qualitative phase: interviews with targeted farmers, food producers, supply chain intermediaries and IFP decision-makers. These aimed to capture the complex institutional dynamics and procurement decision-making processes and to uncover key barriers that influence VBIFP implementation that cannot be revealed through a survey data alone. Interviews provide deeper, more contextual evidence for the forces identified in the framework. This sequential integration methodology facilitated systematic data collection and understanding of the interplay of institutional forces, VBIFP adoption behaviors, and market barriers (Creswell & Clark, 2017).

Quantitative Approach

From December 2020 to March 2021, producers within a 300-mile (483-km) radius of Chicago, mainly in Illinois, Indiana, Michigan, and Wisconsin, were invited to participate in an online survey. They were contacted via email through convenience networks, leveraging listservs at Chicago Food Policy Action Council (CFPAC), Illinois Stewardship Alliance, University of Illinois, Michigan State University, and University of Wisconsin-Madison. Efforts were made to recruit underrepresented producers, including persons identifying as women and/or BIPOC. Producers reported on owner demographics, business characteristics, values-based practices (nutrition, labor, sustainability, animal welfare, local economies), and associated benefits, barriers, and operational challenges. The survey (instrument is in Supplemental File 1) was reviewed by experts and pre-tested with five producers.

Responses from companies located outside the Midwest region were excluded, ensuring geographical scope, as were answers collected under 300 seconds (a threshold data quality control based on a timed-completion exercise of the full survey).

This yielded 189 valid company-level responses and 32,870 item-level observations from 140 binary dummy variables (i.e., implemented/not implemented) after cleaning. Chi-square independence tests in SAS evaluated statistically significant associations between categorical variables. This is an appropriate nonparametric approach for binary data examining relationships between firm characteristics, values-based practices adoption, perceived benefits, and challenges. Given the large number of tests performed, we applied a conservative interpretation focusing on associations with p values ≤ 0.05 and effect sizes (Cramer's $V \gtrsim 0.20$). The findings section highlights these significant associations.

Qualitative Approach

From fall 2023 through summer 2024, semi-structured interviews (interview questions are in Supplemental File 2) were conducted with 12 stakeholders to generate insights about VBIFP adoption barriers highlighted in the survey and supplier selection processes. Purposive sampling (Creswell & Clark, 2017) drawing on professional networks was used to identify interview participants with knowledge and direct roles in institutional food procurement. The interviewees were independent from survey respondents and included representatives from the City of Chicago ($n = 2$), Cook County ($n = 3$), a private hospital ($n = 1$), food service management companies (FSMCs, $n = 4$) representing buyers' perspectives, along with distributors and aggregators ($n = 2$), farmers ($n = 2$) and food producers ($n = 1$), representing sellers' perspectives. Topics included governance, manuals and regulations for purchasing decisions, operational workflows, supplier relationship management, GFPP implementation strategies and evaluation criteria, challenges, and supply chain adaptations. Interviews averaged 70 minutes.

Two researchers coded and analyzed the interviews using Braun and Clarke's (2006) thematic framework (familiarizing with the data, generating initial codes, searching themes, reviewing themes, defining and naming themes, producing reports), guided by institutional theory and resource-based theory supported by memo-writing and visual mapping. Finally, the qualitative themes were compared against quantitative patterns to identify concurrent evidence and explanatory understandings of statistical associations. This integrative step synthesized findings from both phases, producing a cohesive interpretation that links statistical trends with contextual insights.

Findings

Table 1 presents respondents' demographic and business characteristics. Key highlights reflect deliberate efforts to ensure diverse representation among producers. Specifically, micro and small producers, with sales between $10K and $250K, represent 80% of respondents, a direct result of targeted outreach. The sample also includes an overrepresentation of BIPOC (12%) producers relative to their representation in the broader farming population (USDA, 2019). By doing so, we aim to capture perspectives from groups most often excluded from institutional procurement systems and provide context for the adoption and barrier patterns reported below.

Adoption of VBIFP Practices by Size and Ownership (RQ1)

Our analysis of adoption patterns reveals clear differences by firm size and ownership status (see Appendix, Table A1). Smaller firms and BIPOC-owned firms disproportionally engaged in values-aligned practices. Micro and small producers reported a significantly higher adoption of seasonal production practices (74% and 71%, respectively) versus medium (33%) and large (55%); ($\chi^2 = 12.38$, $p < 0.01$, Cramer's $V = 0.25$). Similarly, BIPOC producers were nearly twice as likely as non-BIPOC producers to cultivate culturally significant crops that relate to the cultural heritage of specific communities (74% versus 39%; $\chi^2 = 9.93$, $p < 0.01$, Cramer's $V = 0.23$).

While producers across all sizes adopted sustainability practices, differences emerged for practices such as composting organic waste (66% overall, with more prevalence among micro (74%) and small (70%) producers; $\chi^2 = 11.68$, $p = 0.0086$, df=3, Cramer's $V = 0.25$), practicing regenerative agriculture (60% overall, with higher prevalence among small producers (70%), and avoiding hazardous chemicals (70% overall; 83% and 77% for

medium and small producers, respectively; χ^2 = 19.75, $p < 0.001$, *df*=3, Cramer's $V = 0.32$). Animal welfare practices were infrequently reported and showed no significant associations.

Labor and equity-related practices varied systematically. Larger businesses had a nearly universal adoption of safety practices, versus 39% of micro-producers ($\chi^2 = 22.85$, $p < 0.001$, *df*=3, Cramer's $V = 0.35$). BIPOC producers reported higher safe labor and healthy working conditions practices than non-BIPOC (78% vs 58%, respectively; $\chi^2 = 3.52$, $p < 0.06$, $df = 1$, Cramer's $V = 0.14$). Diversity-focused hiring practices were more common in larger businesses for local communities (75%), women (70%), and BIPOC individuals (60%), compared to smaller counterparts ($\chi^2 = 22.79$, $p < 0.0001$, *df*=3, Cramer's $V = 0.35$ for local; $\chi^2 = 17.99$, $p < 0.0004$, *df*=3, Cramer's $V = 0.31$ for women; and $\chi^2 = 9.13$, $p < 0.0276$, *df*=3, Cramer's $V = 0.22$ for BIPOC). However, BIPOC-owned enterprises showed significantly higher commitment to diverse hiring, particularly BIPOC workers (70% vs. 29% for non-BIPOC, $\chi^2 = 14.90$, $p < 0.001$, *df*=1, Cramer's $V = 0.28$), women (65% vs 44%), and socially disadvantaged groups (52% vs 24%).

Nearly half of producers (48%) reported collaborating with nonprofits and/or government agencies and participating in activities to support local economies, with BIPOC significantly more likely to engage ($\chi^2 = 7.25$, $df = 1$, $p = .0071$, Cramer's $V = .20$). Purchasing practices reflected this commitment: 78% prioritized SME suppliers, 73% favored small, family or cooperative-owned operations, and 69% sourced within the same county. Similarly, BIPOC-owned businesses showed a strong preference for purchasing from other BIPOC suppliers as compared to non-BIPOC-owned businesses (70% vs. 21%; $\chi^2 = 24.10$, $p < 0.0001$, $df = 1$, Cramer's $V = 0.36$).

Table 1. Characteristics of Producers in the Sample (*N* = 189) (All currencies in US$)

Approximate annual sales	**(%)**
Less than $10,000	24
$10,000–$24,999	15
$25,000–$49,999	13
$50,000–$99,999	15
$100,000–$249,999	13
$250,000–$499,999	10
$500,000–$999,999	4
$1,000,000–$4,999,999	6
Greater than $5,000,000	1
Size	
Micro	24
Small	56
Medium	10
Large	11
State	
Illinois	38
Michigan	33
Wisconsin	19
Indiana	8
Other inside the region	2
Profit Orientation	
Traditional	86
Social orientation	14

Gender (%)	**%**
Female	59
Male	36
Other	3
Prefer not to say	2
Agriculture Specialization (multiple choice)	
Specialty Crops	69
Animal Production	28
Fruit & vegetable preserving and specialty food manufacturing	14
Commodity Crops	13
Dairy products	4
Other	31
Ownership (multiple choice)	
Family-owned business	51
Woman-owned business	36
Black, Indigenous or Person of Color-owned business	12
Veteran-owned business	7
Business owned by persons with disabilities	4
Worker-owned cooperative business	4
Minority/Women-Owned Business Enterprise (MWBE) certified	3
Other	6
None	21

Associations by business size have 52% of micro-enterprises prioritizing women-owned suppliers, followed by small (43%), medium (11%) and large producers (25%) ($\chi^2 = 11.31$, $p < 0.011$, $df = 3$, Cramer's $V = 0.24$).

Sales channels reflected size-related differentiation. Direct-to-consumer models dominated overall: 61% sold in-person and 50% sold online. Smaller operations were more likely to engage in these channels: 70% of small producers sold through farmers markets, compared to 56% of medium and 30% of large producers ($\chi^2 = 14.18$, $p < 0.003$, $df = 3$, Cramer's $V = 0.27$). By contrast, while nearly half of small (46%), medium (44%), and large (40%) producers sold to restaurants and food service providers, only 13% of micro producers did so ($\chi^2 = 14.18$, $p < 0.003$, $df = 3$, Cramer's $V = 0.27$). Similarly, community supported agriculture (CSA) programs showed a moderate association with business size, with more smaller operations engaged in them.

These patterns indicate that while smaller and minority-owned business producers may lack resources, they often adopt VBIFP practices more fully than larger operations. Larger businesses more often adopted formal safety measures. BIPOC-owned businesses reported higher engagement in diversity hiring. Similarly, BIPOC-producers were significantly more likely to support economic development initiatives. Further, results reflect clear differentiation by size in terms of sales channel strategy, with smaller producers opting more heavily to sell through direct-to-consumer channels.

Systemic Barriers that Limit Access to Institutional Markets (RQ2)

Seven percent of respondents reported sales to institutions. Two coercive requirements emerged as the most significant barriers: volume thresholds and certification requirements.

Volume thresholds were the most frequently cited challenge, with 34% of producers citing insufficient volume to meet institutional demand. This constraint was strongly associated with business size ($\chi^2 = 22.19$, $p < 0.0001$, Cramer's $V = 0.34$), indicating that smaller producers are systematically disadvantaged by minimum volume requirements.

Certification requirements also block market access. One third of producers reported operating without any certification, a factor associated with business size ($\chi^2 = 6.54$, $p = 0.0881$, $df = 3$, Cramer's $V = 0.19$). Among those with certifications, Food Safety Modernization Act (FSMA) training was the most prevalent (held by 30% of respondents), and also showed significant variation by size ($\chi^2 = 8.56$, $p = 0.0356$, $df = 3$, Cramer's $V = 0.21$). No significant associations were found between certification status and owner demographics.

Beyond these formal requirements, structural resource constraints were also cited as access barriers. Financial constraints emerged as the most reported barrier overall (52%) and were disproportionally cited by BIPOC producers (78% vs. 49%; $\chi^2 = 7.03$, $p = 0.0080$, $df = 1$, Cramer's $V = 0.19$). Lack of additional land or infrastructure resources (39% overall) also showed a strong statistical association with ownership, with BIPOC producers twice as likely as non-BIPOC producers to face them (70% vs. 35%; $\chi^2 = 10.17$, $p = 0.0014$, $df = 1$, Cramer's $V = 0.23$). Access to capital was another critical constraint reported by 33% of all respondents, and more than twice as frequently among BIPOC farmers (65% vs. 30%; $\chi^2 = 11.50$, $p = 0.0007$, $df = 1$, Cramer's $V = 0.25$).

Labor availability showed a significant association with business size ($\chi^2 = 12.27$, $p = 0.0065$, $df = 3$, Cramer's $V = 0.25$), affecting medium-sized business the most (61%), followed by small (34%), large (25%), and micro (17%) producers as a barrier to institutional access.

These findings show that coercive (volume and certification) requirements combined with persistent financial, land, and capital constraints systematically disadvantage smaller and minority-owned businesses, limiting their access to institutional food markets.

Buyer-side Constraints Limiting VBIFP Adoption (RQ3)

Interviews with institutional buyers and FSMC representatives highlighted how institutional pressures also exclude smaller, values-aligned suppliers from their supply chains. Based on semi-structured interviews, these dynamics align with the framework in Figure 1, each reflecting financial, technological,

and logistical constraints that define procurement mechanisms and reinforce the access frictions described under RQ2. These are summarized in Figure 2.

Coercive and Normative Pressures: The interviews revealed that public and private institutional food procurement decisions were consistently driven by cost-efficiency norms and volume expectations. As one procurement officer explained, "The vendor with the lowest overall cost wins the contract." Because institutional contracts rank lower-cost bids higher, smaller producers who could not compete on price are effectively sidelined, despite being well aligned with VBIFP goals. Institutional buyers also described the challenge of balancing multiple GFPP pillars; that is, advancing one objective (such as local sourcing) could conflict with another (such as sustainability). These tensions reflect how evaluation criteria and standards function as normative constraints that reinforce a culture of trade-offs rather than holistic assessment to navigate competing priorities.

Mimetic Pressures: Contracting favors incumbent suppliers or new players who can demonstrate similar size and operational capabilities. Even when procurement officers support values-based purchasing, they may have little oversight of, or influence over, supplier selection if their food contracts are managed by FSMCs. As one interviewee stated, "We have no control over the awarding of contracts. … If we find a product that aligns with our goals, we can share it with the management companies for consideration. Ultimately, the decision to purchase is in their hands." The reliance on FSMC-managed contracts limits flexibility. Supply aggregation was seen as a potential solution to meet volume and certification requirements. As one interviewee noted,

> Small-scale producers lacking formal certification may complete our safety procedures to demonstrate alignment with required standards. We assume the risk of small-volume operations; however, as their volume increases, formal certification becomes necessary. To ensure that growth does not lead to market exclusion, we further support producers in pursuing them.

But buyers recognized the difficulty of organizing small producers, who often lack the financial resources and technical know-how, to create food hubs. As another procurement officer stated, "Unless they get together and form their own group or subcontract, there's nothing we can do."

Figure 2. Values-based Institutional Food Procurement Challenges (Thematic Map from Interviews)

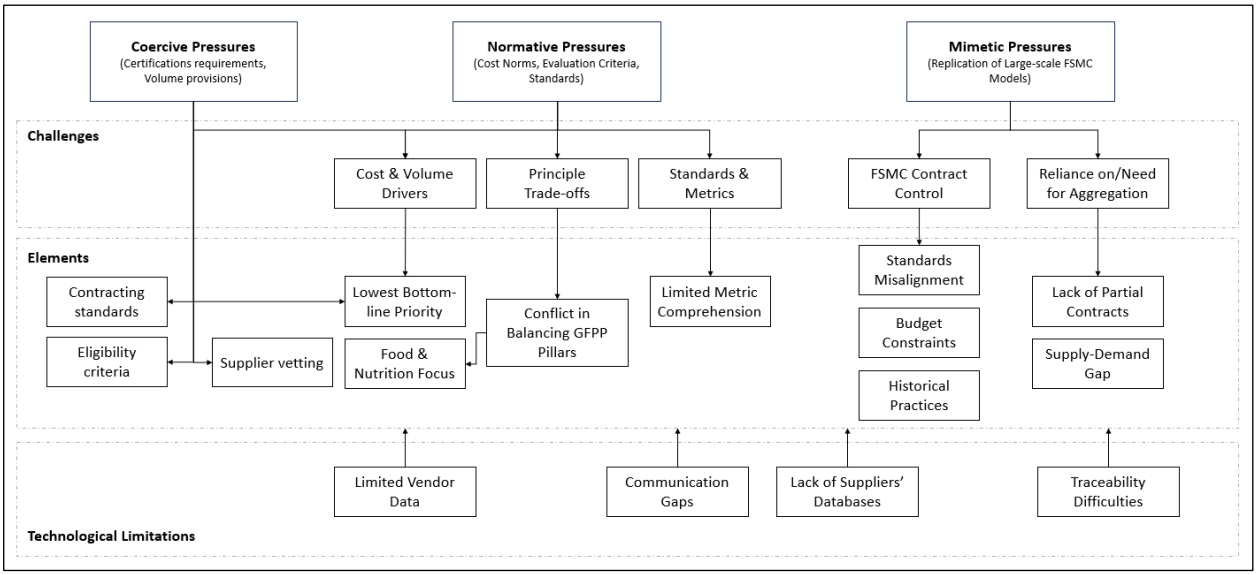

Figure created by the authors for this study.

Technological Limitations: These institutional pressures were reinforced by gaps in information technology (IT) and data infrastructure. Buyers noted that many institutions lacked the systems to track supplier compliance with VBIFP principles, and smaller producers often lack the IT infrastructure to maintain such records, making them non-competitive in institutional markets. As one interviewee noted, "The bigger ones tend to have data, but the smaller ones don't. And if they do, they're usually priced out of the market." Moreover, the lack of open-access, updated supplier databases hampered efforts to identify values-aligned vendors, slowing the progress towards VBIFP adoption.

These findings show how coercive and normative expectations such as cost-driven standards and mimetic mechanisms tied to FSMC models and aggregation requirements, compounded by technological limitations, curtail institutional buyers' ability to implement VBIFP, even when there is strong commitment to values-based procurement.

Discussion

This study provides the empirical evidence on the adoption of values-based practices among U.S. Midwest producers and elucidates the ways institutional pressures limit the inclusion of smaller and BIPOC-owned businesses in IFP despite their values-aligned practices adoption. It demonstrates how internal and external dynamics jointly affect VBIFP implementation using an institutional and resource-based theoretical lens. Current institutional procurement systems are not well equipped to accommodate smaller producers into VBIFP. Coercive requirements such as certifications and volume thresholds, while intended to ensure compliance and efficiency, perpetuate structural advantages that favor large-scale producers while systematically excluding smaller producers (Grob & Benn, 2014; Hatanaka et al., 2005; Oya et al., 2018). One third of surveyed producers, particularly small and micro-operators, lack formal certifications, and our interviews confirmed that certification rules are applied rigidly as evaluation criteria, imposing disproportionate costs and administrative burdens on smaller producers. Volume and process standardization requirements similarly exclude smaller producers. Normative pressures also perpetuate exclusion through cost-based contract evaluations that prioritize lowest-price bids, reinforcing "cost-based contracting culture" (Izumi et al., 2010). These disadvantage producers offering local, sustainable, and culturally relevant foods, which typically carry higher prices (Belletti et al., 2020; Lehtinen, 2012; Minkoff-Zern, 2019), limiting institutions' ability to integrate values-based criteria for supplier selection.

Despite facing these structural challenges, small and BIPOC producers demonstrated significant values-based capabilities. Survey results showed greater adoption of seasonal production, culturally relevant and nutrient-rich crops, sustainability practices, and local economic engagement among these groups, extending prior findings on cultural capital and terroir to the VBIFP context (Charters et al., 2017; Minkoff-Zern, 2019). Smaller producers also leveraged their unique local knowledge, proximity to regional markets, and direct-to-consumer channels to gain a competitive advantage. BIPOC producers, for their part, prioritized hiring from historically marginalized groups and supporting other BIPOC-owned businesses to create pathways for community empowerment and economic resilience, which is consistent with findings in the collective agency literature (Nunoo, 2023). These findings suggest that despite structural impediments, small and minority-owned businesses engage in and embody many of the principles VBIFP seeks to advance. However, their capabilities remain undervalued in wholesale channels and procurement scoring systems, where formal certifications and cost efficiency dominate.

These insights suggest institutional procurement reforms that reduce coercive and normative barriers while establishing mechanisms to recognize and reward the distinct capabilities of smaller and minority-owned producers. We suggest actions that stakeholders could take to close the VBIFP implementation gap.

Institutions and FSMCs

- Revise scoring criteria to include values-aligned practices beyond certifications.
- Pilot partial, seasonal, or quota-based contracts

to better match small suppliers' realities.
- Partner with food hubs or cooperatives for aggregation and supply consistency.
- Adopt interoperable systems using standardized language and metadata frameworks, ensuring compatibility and transparency.
- Provide legal technical assistance for navigating contracts.

Policymakers
- Subsidize or create tiered pathways for certifications (e.g., grants, cost-sharing).
- Develop vendor databases to reduce information gaps.
- Facilitate and/or subsidize traceability and compliance tools for small producers so they can meet procurement standards.
- Permit waivers for flexible eligibility and contracting rules.
- Invest in technological infrastructure (platforms for improved supply-demand matching and certification compliance).
- Set data governance protocols, standards, and incentives to ensure interoperable systems, standardized language, and metadata frameworks.

Producers
- Pursue aggregation strategies through food hubs and cooperatives to meet volume and certification requirements.
- Strengthen institutional partnerships for trust and visibility.
- Document values-aligned practices in standardized formats that can be assessed by buyers.
- Engage in peer-to-peer "best practices" training initiatives to share knowledge on meeting procurement standards and scaling operations.

Limitations and Future Research
The generalizability of this research is constrained by several factors, including the use of convenience networks, small subgroup sample sizes, and the study's focus on Metro Chicago institutions. These limitations introduce potential selection bias, and the findings should therefore be interpreted as context-specific insights rather than representative of all U.S. Midwestern producers and institutional buyers. Furthermore, the cross-sectional nature of the data prevents us from establishing causal relationships or assessing how producer characteristics and values-based practices evolve over time.

Future research could test these findings using larger and more representative samples across regions and institutional contexts. Additional work is needed to evaluate the effectiveness of policy interventions aimed at institutionalizing VBIFP, including local sourcing requirements, procurement preferences for vendors who integrate sustainable and local suppliers, and the adoption of more flexible procurement mechanisms. Research could also examine how small-scale and ethnic-minority producers can strategically leverage their cultural, geographical, and community-based assets to strengthen their competitive position within VBIFP.

Further investigation is warranted into the potential of cooperative models, food hubs, and other collaborative efforts to help small producers aggregate their goods and collectively meet institutional requirements. Given the technological barriers identified in this study, future research is needed to explore how data-driven models and digital platforms could improve supply-demand matching, supply coordination, and traceability and compliance verification. Finally, additional empirical work is needed to quantify the economic multiplier effects of VBIFP adoption on local communities.

While this study focuses on small-scale and BIPOC producers due to their underrepresentation in institutional markets, this does not imply that values-based supply chains should exclusively support small businesses. Large enterprises can and do operate with strong values-based commitments, and future research could examine these different organizational-scale contexts, strategies, and outcomes.

Conclusion
This study's findings suggest that institutional pressures—rather than a lack of values-alignment—are the primary factors that limit producers' participation in institutional food procurement in the U.S. Midwest. Small and BIPOC producers reported higher adoption of values-aligned practices, includ-

ing the cultivation of seasonal and culturally relevant crops, implementation of sustainability measures, diversity hiring, and community engagement. However, coercive requirements (e.g., certifications and volume thresholds), normative cost-based criteria, and mimetic reliance on food service management companies' (FSMC) procurement models continue to restrict their participation in institutional markets. At the same time, structural resource constraints related to financing, land, and capital access further limit producers' ability to meet institutional requirements despite strong alignment with VBIFP goals.

Closing these implementation gaps requires a multipronged approach. In the short term, institutions and FSMCs can revise scoring criteria and pilot such flexible mechanisms as partial or seasonal contracts within existing procurement frameworks. These efforts can help determine whether flexible contracts and aggregation models enable smaller suppliers to reliably meet volume and certification requirements. Partnerships with aggregators can also provide producers with access to certification expertise and compliance support, reducing barriers to entry into institutional markets.

Policymakers can further reduce participation barriers by subsidizing certification costs, introducing tiered certification pathways, and investing in shared traceability systems and vendor databases to improve market visibility and reduce information gaps. At the producer level, strengthening cooperative aggregation strategies and expanding training opportunities can help smaller suppliers to scale operations and meet institutional procurement standards. Together, these measures can alleviate institutional pressures facing both buyers and suppliers and better align procurement practices with the goals of values-based institutional food procurement.

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Appendix

Table A1. Main Survey Results and Chi-Squared Independent Test by Size and BIPOC Characteristic (*N* = 189)

		Size				BIPOC			
Description	**Sample %**	**χ^2**	**df**	***p*-value**	**Cramer's *V***	**χ^2**	**df**	***p*-value**	**Cramer's *V***
Sales channels implemented									
In-person direct to consumer	61	7.08	3	0.0694*	0.19	0.26	1	0.6099	–
Farmers market	59	14.18	3	0.0027***	0.27	0.05	1	0.824	0.02
Online direct to consumer	50	13.09	3	0.0045***	0.26	0.41	1	0.5219	–
Restaurant and/or food service providers	37	15.25	3	0.0016***	0.28	1.34	1	0.2459	–
Community Supported Agriculture (CSA)	36	8.70	3	0.0336**	0.21	1.59	1	0.2065	0.09
Distributors, wholesalers, aggregators	20	--	--	--	--	--	--	--	--
Food hub	14	--	--	--	--	--	--	--	--
Co-operative grocery	13	--	--	--	--	--	--	--	--
Conventional grocery	11	--	--	--	--	--	--	--	--
Institutional buyers (e.g., schools, hospitals)	7	--	--	--	--	--	--	--	--
Certifications implemented									
None	33	6.54	3	0.0881*	0.19	0.40	1	0.5292	0.04
Food Safety Modernization Act	30	8.56	3	0.0356**	0.21	0.16	1	0.6914	–
Other certifications	19	--	--	--	--	--	--	--	--
Good Agricultural Practices (GAP)	11	--	--	--	--	--	--	--	--
Illinois Food Sanitation	9	--	--	--	--	--	--	--	--
Safe Food Certifications	7	--	--	--	--	--	--	--	--
FDA Food Facility Registration	4	--	--	--	--	--	--	--	--
Benefits from implementing									
Increased customer satisfaction	76	--	--	--	--	0.10	1	0.7566	0.02
Improved brand image	68	0.90	3	0.8243	0.07	0.39	1	0.5339	0.05
Increased market opportunity	62	5.21	3	0.1568	0.17	0.03	1	0.8687	–
Increased productivity and/or output	46	3.40	3	0.3335	0.13	0.06	1	0.8113	0.02
Ensured compliance with food-related laws	45	5.92	3	0.1153	0.18	2.24	1	0.1348	–
Increased employee satisfaction	40	10.39	3	0.0155**	0.23	1.04	1	0.3076	–
Increased owner or shareholder satisfaction	37	3.23	3	0.357	0.13	0.03	1	0.8545	–
Reduced operational costs	34	0.16	3	0.9836	0.03	0.32	1	0.5689	0.04
No benefits	19	--	--	--	--	--	--	--	--
Other benefits	7	--	--	--	--	--	--	--	--
Difficulties of implementing									
Lack of financial resources to implement practices	52	2.92	3	0.4044	0.12	7.03	1	0.0080***	0.19
Lack of additional land or infrastructure/resources needed to implement practices	39	2.60	3	0.4571	0.12	10.17	1	0.0014***	0.23
Lack of assistance from farmer-focused organizations	25	--	--	--	--	1.38	1	0.2405	0.09
No way to signal implementation of practice to customers	23	--	--	--	--	1.40	1	0.236	–

Description	Sample %	Size				BIPOC			
		χ^2	df	*p*-value	Cramer's *V*	χ^2	df	*p*-value	Cramer's *V*
No government policies that mandate implementation of practices	17	--	--	--	--	--	--	--	--
No demand from customers	12	--	--	--	--	--	--	--	--
Challenges to growing your farming operations and farm income									
Limited access to capital	34	5.59	3	0.1333	0.172	11.50	1	0.0007***	0.25
Limited availability of labor	32	12.27	3	0.0065***	0.2548	9.07	1	0.0026***	--
Changing weather patterns (e.g., drought, flooding, storms)	27	7.59	3	0.552**	0.2004	6.81	1	0.0091***	--
COVID-19	24	--	--	--	--	0.59	1	0.4406	--
Other challenges	21	--	--	--	--	--	--	--	--
Reasons not selling to institutional buyers									
Insufficient product volume to meet demands of large orders	34	22.19	3	<0.001***	0.34	6.00	1	0.0143**	0.18
Insufficient capacity to enter contracts or MOUs (e.g., legal status, required certifications)	17	--	--	--	--	--	--	--	--
No relationships with institutions or contractors	17	--	--	--	--	--	--	--	--
Lack of shared facilities to collaborate (warehousing, processing or kitchen space)	11	--	--	--	--	--	--	--	--
Lack of food hubs/distributors/aggregators that source from local producers	10	--	--	--	--				
Nutritional practices									
Growing locally seasonal fruits and vegetables	67	12.38	3	0.0062***	0.25	2.99	1	0.0835*	0.13
Choosing culturally relevant, nutrient-rich crops	43	8.14	3	0.0431**	0.20	9.93	1	0.0016***	0.23
Produce value-added products	39	2.76	3	0.4346	0.12	0.83	1	0.3656	--
Choosing heritage breeds	38	2.74	3	0.4333	0.12	0.12	1	0.727	--
Other nutritional practices	19	--	--	--	--	--	--	--	--
Labor practices									
Building safe and healthy working conditions	60	22.85	3	0.0001***	0.35	3.52	1	0.0605*	0.14
Eliminating discrimination with respect to employment or occupation	41	12.65	3	0.0051***	0.26	1.28	1	0.257	0.08
Eliminating all forms of forced or compulsory labor	34	5.10	3	0.1647	0.16	0.96	1	0.3276	0.07
Restricting the employment and abuse of children as workers	34	7.09	3	0.0688**	0.19	0.14	1	0.7109	--
Respecting employees' freedom of association and collective bargaining	23	--	--	--	--	3.68	1	0.0550**	0.14
Sustainability practices									
Avoid use of potentially hazardous or toxic chemicals in operations	70	19.75	3	0.0002***	0.32	0	1	0.9754	--
Compost organic waste	66	11.68	3	0.0086***	0.25	0.13	1	0.7109	0.03
Practice regenerative agriculture	60	12.89	3	0.0049***	0.26	0.15	1	0.6914	--
Purchase local raw materials	57	1.10	3	0.776	0.08	0.82	1	0.3642	--
Reduce carbon footprint	52	2.92	3	0.4032	0.12	0.75	1	0.3844	0.06
Ensure workplace conditions are healthy and safe	52	5.88	3	0.1176	0.18	3.25	1	0.0714**	--

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Description	Sample %	Size				BIPOC			
		χ^2	df	*p*-value	Cramer's *V*	χ^2	df	*p*-value	Cramer's *V*
Animal welfare practices									
Animal housing, management, care, and use	23	--	--	--	--	7.96	1	0.0048***	--
Utilize "high welfare" farming practices (e.g., access to pasture, easy access to food and fresh water)	21	--	--	--	--	--	--	--	--
Prevent pain, injury or disease to animals by rapid diagnosis and treatment	19	--	--	--	--	--	--	--	--
Purchase animal products from sources that have third party certifications for high welfare practices	6	--	--	--	--	--	--	--	--
Have operations certified by a recognized animal welfare certification scheme or standard	5	--	--	--	--	--	--	--	--
Local economies									
Work with other organizations (e.g., businesses, not-for-profit organizations, government agencies) to support local economic development activities	48	3.75	3	0.2892	0.14	7.26	1	0.0071***	0.20
Support local workforce development (e.g., hire graduates of workforce training programs)	18	--	--	--	--	--	--	--	--
Establish contracts, partnerships or MOUs with community-serving business or organization with mission to serve disadvantaged populations	12	--	--	--	--	--	--	--	--
Establish formal hiring policy prioritizing local residents with barriers to employment	9	--	--	--	--	--	--	--	--
Other local economies practices	6	--	--	--	--	--	--	--	--
Diversity hiring practices									
Hire persons from local community	48	22.79	3	<0.0001***	0.35				
Hire women	47	17.99	3	0.0004***	0.31	3.66	1	0.0556*	0.14
Hire BIPOC (Black, Indigenous, People of Color) persons	34	9.13	3	0.0276**	0.22	14.90	1	0.0001***	0.28
Hire persons who are socially disadvantaged	28	12.30	3	0.0064***	0.26	7.98	1	0.0047***	0.21
Hire LGBTQ (lesbian, gay, bisexual, transgender, queer) persons	27	11.56	3	0.0090***	0.25	11.59	1	0.0007***	0.25
Prioritized purchasing practices									
Small and medium-sized businesses	78	--	--	--	--	0.00	1	0.9526	0.00
Farmer-owned (small-scale, family, or cooperatively owned) business	73	2.57	3	0.4623	0.12	1.96	1	0.1614	--
Businesses located within the same county as your business	69	0.71	3	0.869	0.06	0.88	1	0.3489	--
Businesses located within 300 miles of your business	52	4.09	3	0.2514	0.15	0.00	1	0.9737	0.00
Women-owned businesses	40	11.31	3	0.0105*	0.24	9.39	1	0.0022***	0.22
Black, Indigenous, People of Color (BIPOC)-owned businesses	27	6.24	3	0.1003	0.18	24.10	1	<0.0001***	0.36

Notes: *, **, and *** signify statistical significance at the 0.1, 0.05, and 0.01 levels, respectively
Chi-squared values are not reported for cases where some expected cell counts are below 5

Table A2. Frequency Table of Survey Results by Firm Size

Table entries represent **the number of producers (percentage of group).**
X (Y%): X is the number of engaged producers and Y% is their proportion within the group.

Category	Description	Large *n* = 20	Medium *n* = 18	Small *n* = 105	Micro *n* = 46
Sales channels	In-person Direct to Consumer	7 (35%)	13 (72%)	67 (64%)	29 (63%)
	Farmers Market	6 (30%)	10 (56%)	73 (70%)	22 (48%)
	Online Direct Consumer	6 (30%)	11 (61%)	62 (59%)	15 (33%)
	Restaurant and/or Food Service Providers	8 (40%)	8 (44%)	48 (46%)	6 (13%)
	Community Supported Agriculture (CSA)	2 (10%)	7 (39%)	45 (43%)	14 (30%)
Certification	No certifications	3 (15%)	8 (44%)	32 (30%)	20 (43%)
	Food Safety Modernization Act	5 (25%)	3 (17%)	40 (38%)	8 (17%)
Diversity hiring	Hiring local community talent	15 (75%)	11 (61%)	55 (52%)	9 (20%)
	Hiring women	14 (70%)	11 (61%)	53 (50%)	10 (22%)
	Hiring BIPOC	12 (60%)	6 (33%)	36 (34%)	10 (22%)
	Hiring social disadvantaged persons	9 (45%)	3 (17%)	35 (33%)	5 (11%)
	Hiring LGBT	10 (50%)	2 (11%)	32 (30%)	7 (15%)
Purchasing practices	Purchasing from women-owned business	5 (25%)	2 (11%)	45 (43%)	24 (52%)
Nutrition	Growing locally seasonal fruits and vegetables	11 (55%)	6 (33%)	75 (71%)	34 (74%)
Labor	Building safe and healthy working conditions	20 (100%)	13 (72%)	63 (60%)	18 (39%)
	Eliminating discrimination with respect to employment or occupation	15 (75%)	7 (39%)	43 (41%)	13 (28%)
Sustainability	Avoid use of potentially hazardous or toxic chemicals in operations	6 (30%)	15 (83%)	81 (77%)	30 (65%)
	Compost organic waste	7 (35%)	10 (56%)	74 70%)	34 (74%)
	Practice regenerative agriculture	7 (35%)	11 (61%)	74 (70%)	22 (48%)
Challenges for selling to institutions	Insufficient product volume	2 (10%)	2 (11%)	33 (31%)	27 (59%)
Operations and farm income growing challenges	Limited availability of labor	5 (25%)	11 (61%)	36 (34%)	8 (17%)
	Changing weather patterns	2 (10%)	6 (33%)	35 (33%)	8 (17%)
Benefits	Increased employee satisfaction	14 (70%)	5 (28%)	43 (40%)	14 (30%)

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Table A3. Frequency Table of Survey Results by BIPOC and Non-BIPOC Ownership

Table entries represent **the number of producers (percentage of group)**
X (Y%): X is the number of engaged producers and Y% is their proportion within the group.

Category	Description	BIPOC *n* = 23	No-BIPOC *n* = 166
Diversity hiring	Hiring women	15 (65%)	73 (44%)
	Hiring BIPOC	16 (70%)	48 (29%)
	Hiring social disadvantaged persons	12 (52%)	40 (24%)
	Hiring LGBT	13 (57%)	38 (23%)
Purchasing practices	Purchasing from women-owned business	16 (70%)	60 (36%)
	Purchasing from BIPOC-owned business	16 (70%)	35 (21%)
Nutrition	Growing locally seasonal fruits and vegetables	19 (83%)	107 (64%)
	Choosing culturally relevant, nutrient-rich crops	17 (74%)	65 (39%)
Labor	Building safe and healthy working conditions	18 (78%)	96 (58%)
Local economies	Work with other organizations (e.g., businesses, not-for-profit organizations, government agencies) to support local economic development activities	17 (74%)	73 (44%)
Difficulties from implementing VBIFP practices	Lack of financial resources to implement practices	18 (78%)	81 (49%)
	Lack of additional land/infrastructure/resources needed to implement practices	16 (70%)	58 (35%)
Top challenges to growing your farming operations and farm income	Limited access to capital	15 (65%)	49 (30%)

Table A4. Frequency Table by State and Chi-square Independency Test Results

Table entries represent **the number of producers (percentage of group)**

X (Y%): X is the number of producers from given state and Y% is their proportion within the group.

Category	Description	χ^2	df	*p*-value	Cramer's *V*	Illinois	Indiana	Michigan	Other	Wisconsin
Nutrition	Choosing culturally relevant, nutrient-rich crops	8.71	4	0.0686*	0.21	39 (55%)	4 (27%	21 (33%)	3 (60%)	15 (43%)
	Choosing heritage breed	12.97	4	0.0114**	0.262	35 (50%)	4 (27%)	14 (22%)	2 (40%)	17 (49%)
Sustainability	Practice regenerative agriculture	28.82	4	<0.0001***	0.39	47 (66%)	13 (87%)	22 (35%)	4 (80%)	28 (80%)
	Reduce carbon footprint	11.89	4	0.0181**	0.25	41 (58%)	12 (80%)	25 (40%)	1 (20%)	20 (57$)
	Reduce water footprint	8.57	4	0.0728*	0.21	34 (48%)	10 (67%)	21 (33%)	2 (40%)	20 (57%)
	Compost organic waste	8.83	4	0.0654*	0.21	55 (77%)	10 (67%)	34 (54%)	4 (80%)	22 (63%)
	Ensure workplace conditions	11.69	4	0.0197**	0.25	39 (55%)	13 (87%)	27 (43%)	1 (20%)	19 (54%)
Local economies	Work with other organizations to support local economic development activities	10.59	4	0.0315**	0.24	43 (61%)	6 (40%)	21 (33%)	2 (40%)	18 (51%)
Difficulties from implementing VBIFP practices	Lack of additional land/infrastructure/resources needed to implement practices	11.03	4	0.0262**	0.24	37 (52%)	2 (13%)	23 (37%)	2 (40%)	10 (29%)
Top challenges to growing your farming operations and farm income	Limited access to capital	8.77	4	0.0667*	0.22	25 (35%)	7 (47%)	14 (22%)	1 (20%)	17 (49%)

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From fields to markets: Diversification case studies in the U.S. Corn Belt via a social-ecological systems lens

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Abstract

Agricultural diversification is increasingly recognized as a systems-level strategy that enhances sustainability, resilience, and adaptability of agricultural and food systems under global environmental and market pressures. This research delves into the dynamics, opportunities, challenges, and key success drivers associated with agricultural diversification in the U.S. Midwest—a region historically dominated by corn–soybean rotations—through the lens of the social-ecological systems (SES) framework. Focusing on the integration of oats, wheat, and peas into existing systems, we employed a case study methodology combining theoretical, empirical, and contextual inquiry. Data collection integrates primary and secondary sources, including semi-structured interviews and participation in field days, spanning October 2022 to February 2024. Interviews with 29 actors, including farmers,

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industry representatives, and members of agricultural cooperatives and nonprofits, provided insights into market opportunities for diversified agriculture systems. The findings highlight that diversification outcomes are co-shaped by ecological interactions, market dynamics, policy environments, and collaborative networks. The cross-case analysis demonstrates that farmer decision making, knowledge co-production, supply chain coordination, and farmer–Extension collaborations are central mechanisms that foster ecological resilience, expand market access, and stimulate innovation. Through the SES framework, this research provides a novel synthesis that advances understanding of agricultural diversification as a system-level transition pathway. Beyond the Midwestern U.S. context, this research contributes to the body of knowledge on how agricultural diversification is a system-level transformation process and to broader debates on agroecology, sustainability transitions, and food system resilience, offering insights to guide future research, policy, and practice.

Keywords
market diversification, case studies, sustainability transitions, resilience, value-chain collaborations, social-ecological systems framework

Introduction
The global dominance of monocultures in agriculture has led to significant economic, ecological, social, and environmental vulnerabilities, including susceptibility to pests, diseases, and market fluctuations (Savary et al., 2019; Zhao et al., 2020). In the U.S., the Midwest Corn Belt is renowned for its high crop productivity, predominantly focused on corn and soybeans (Hart, 1986; Kim & Moschini, 2018), which play a significant role in global agricultural systems through their use in animal feed, biofuels, and food products (Farida & Singagerda, 2021; Tanaka et al., 2023). Yet, the specialization of Corn Belt systems raises concerns about long-term sustainability, climate resilience, and the provision of ecosystem services. Agricultural diversification has emerged as a crucial pathway for transitioning dominant monoculture production models toward more sustainable, resilient, and agroecological food systems. Evidence suggests that agricultural diversification is a necessary strategy for enhancing resilience and sustainability in worldwide agricultural systems (Han, 2021; Meraner et al., 2018; Prokopy et al., 2020; Roesch-McNally et al., 2018; Shirriff et al., 2022). From the social-ecological systems perspective, diversification is not merely a farm-level choice, but a systems-level adaptation that involves

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Ethics Approval and Consent to Participate
This study was approved by the Purdue University Institutional Review Board under IRB-2022-151, and informed consent was acquired from all study participants.

Author Contributions
KP: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing, Figures, Tables. BR: Conceptualization, Formal analysis, Writing – review & editing, Tables. AT: Conceptualization, Methodology, Writing – review & editing. LE: Conceptualization, Data curation, Formal analysis, Writing – review & editing. LP: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Funding Acquisition, Project administration.

Consent for Publication
All authors have read and approved the final version of this manuscript and consent to its submission. Participants consented to the use of their interview responses and related materials for publication.

Availability of Data and Material
The data supporting this study consists of qualitative materials (interview transcripts) that contain identifiable information. Due to ethical considerations, data is not publicly available. However, de-identified excerpts may be provided by the corresponding author upon reasonable request.

Code Availability
Qualitative data were analyzed using NVivo (version 14), as described in the paper.

adapting markets, policies, knowledge networks, and supply chains.

This study examines opportunities and barriers for integrating oats, peas, and wheat into U.S. Midwestern agricultural systems. These crops support agroecological transitions, soil health, diet diversity, and market expansion. We define diversification as adding crops beyond corn-soybean rotations to boost resilience, economic stability, and environmental benefits. While diversification forms include intercropping, agroforestry, and polycultures, we focus on rotational diversification (Baldwin-Kordick et al., 2022; Hathaway, 2016).

Benefits of Introducing Additional Crops

Corn–soybean specialization in the U.S. has reduced crop diversity (Crossley et al., 2021), heightening economic, social, and environmental vulnerabilities (Prokopy et al., 2020). The intensification of these practices has contributed to environmental degradation and compromised the food system's ability to withstand shocks, indicating a pressing need for more resilient and sustainable approaches (Crossley et al., 2021; Prokopy et al., 2020). Diversified rotations can improve soil health, reduce chemical inputs, and increase the adaptability to changing conditions (Baldwin-Kordick et al., 2022; Hathaway, 2016). They also open niche and value-added markets that strengthen farm income and long-term economic stability (Torres et al., 2021). Beyond farm-level benefits, diversification supports risk management, fosters local food systems, and enhances community resilience (Traldi et al., 2024). By buffering against market fluctuations (Barbieri & Mahoney, 2009), diversified agriculture represents a pathway toward sustainable transformation in the U.S. Corn Belt.

Determinants of Crop Diversification

Understanding the multi-scalar drivers of crop diversification is critical for enabling system-level transitions toward sustainable agriculture. Market dynamics shape opportunities for farmers to diversify, particularly through seasonal or niche markets (Bellon et al., 2016; Torres et al., 2021). Reliable markets help buffer price fluctuations, enhance income stability, and strengthen rural resilience (Dube, 2016; Liebman & Schulte, 2015; Wan et al., 2016). Access to infrastructure and proximity to markets strongly influence diversification, while landholding size influences flexibility in introducing new crops (Kannan & Pohit, 2021; Rahman, 2009; Sichoongwe et al., 2014). Commodity interdependencies also affect diversification strategies. In the U.S. Corn Belt, prices of corn and soybeans are closely linked; when markets favor these dominant crops, farmers often prioritize short-term profits over diversification. Conversely, market volatility or declining returns can incentivize diversification as a risk-reduction strategy (Shirriff et al., 2022; Yuan et al., 2020). Other economic factors such as technological advancements, input costs, and infrastructure connectivity are also vital for crop diversification (Lancaster & Torres, 2019; Walo, 2016). Social factors, including norms, networks, and consumer preferences, are also correlated with agricultural diversifications (Ali, 2015; Cecchini et al., 2018; Traldi et al., 2024). Regulatory and incentivizing agricultural policies (i.e., features of governance) significantly impact land use decisions and conservation practices (Diffenbaugh et al., 2012; Lark et al., 2015).

In the U.S. Corn Belt, networks of farmers, marketing arrangements, and improved soil health provide important opportunities for diversification (Traldi et al., 2024). Nonetheless, higher farm revenues are linked to a decreased likelihood of adopting extended rotations (Roesch-McNally et al., 2018). Key barriers include limited markets for alternative crops, high land costs, difficult access to land, labor, and technical support, and the comparative difficulty and time required to diversify (Roesch-McNally et al., 2018; Traldi et al., 2024).

While challenges exist, collaboration among stakeholders is vital to an enabling environment for diversification (Forrest & Wiek, 2021; Hergesheimer & Wittman, 2012; Hills et al., 2013). Collectively, these dimensions—market, economic, social, and governance—are essential for understanding and optimizing markets for agricultural diversification. Farmers' decision-making processes further illustrate the multi-dimensional nature of diversification. Beliefs, perceptions of market access, and risk considerations affect adoption (Arbuckle et al., 2013; Prokopy et al., 2019; Robert et al., 2016; Torres et al., 2017; Torres & Marshall, 2018).

When farmers perceive markets as reliable and profitable, they are more likely to integrate alternative crops and practices (Arbuckle et al., 2013).

Despite growing recognition of diversification benefits, little is known about agricultural transitions to greater crop diversity or new market emergence/stabilization for alternative crops. This paper examines synergies among actors in oats, peas, and wheat markets in the highly specialized Corn Belt. Using a multi-case qualitative approach, we analyze opportunities, challenges, and critical success factors in diversified crop markets. Drawing on 29 interviews and regional field-day observations, we aim to generate system-level insights.

This analysis is guided by the social-ecological systems (SES) framework, which conceptualizes agricultural markets as embedded within interdependent ecological, economic, and social subsystems (McGinnis & Ostrom, 2014; Ostrom, 2009). SES highlights dynamic interactions among resource systems, actors, governance structures, and markets in "action situations" involving decisions, negotiations, and knowledge exchange. In the context of supply chain studies, and contrary to traditional analytical frameworks like the global value-chain approach, SES can help embed supply chains in the context of traditionally externalized and ignored factors, including ecological and social factors that both impact and are impacted by supply chains (Loomis et al., 2026). Applied to diversification, it reveals how collaborations among farmers, buyers, and support organizations shape market trajectories and system resilience (Schlüter et al., 2019). While recent work on diversification in the U.S. Corn Belt often broadly describes market and production challenges and opportunities (e.g., Roesch-McNally et al., 2018; Traldi et al., 2024), this paper more narrowly and deeply focuses on specific cases of successful markets to garner a richer understanding of the specific factors underpinning current and future diversification efforts. This paper examines three Corn Belt markets that illustrate diversification enablers and constraints. Across cases, we identify shared dynamics—agricultural management, market access, governance, and socio-environmental conditions—shaping market resilience and sustainability. The research advances understanding of diversification as system-level transformation and informs sustainable agricultural and food system transition pathways.

Materials and Methods

This research employs a multi-case design grounded in empirical and contextual inquiry (Denzin & Lincoln, 2005; Yin, 2017). Case studies explore specific contexts to gain deeper understandings of different processes, networks, programs, and other phenomena, such as supply chains, making this research approach appropriate for our exploratory study. The focus is on markets for agricultural diversification in the U.S. Midwest, specifically crops that could complement corn–soybean rotations. Using a most-similar systems approach (George & Bennett, 2005; King et al., 2021), three cases were selected—oats (*Avena sativa*), peas (*Pisum sativum*), and wheat (*Triticum spp.*)—to enable cross-case comparison and acquire broader insights into diversification dynamics.

The research addresses three objectives: (1) identify opportunities and challenges in diversified crop markets across markets, economic, social, and governance dimensions; (2) identify key success drivers for market growth; and (3) map challenges, opportunities, and drivers through an SES lens to understand local diversification enablers and constraints. Data came from semi-structured interviews and secondary data review (Baxter & Jack, 2008; Morse, 1991). For each case, units of analysis included actors involved in crop production and crop entry into the value chain: growers, primary and secondary processors, and supporting organizations along each crop's value chain; actors further along the value chain, including distribution, retail, and consumers, were excluded.

Purposeful Selection

Case studies were chosen collaboratively with the Diverse Corn Belt (DCB) project network (Diverse Corn Belt Project, 2022) via a systematic multistep process. A detailed matrix drawing on literature review categories (Table 1) was developed to inform key analytical dimensions considered relevant for understanding diversification processes, rather than to identify cases directly through a structured search protocol. Initial assessments used public information (websites, social

Table 1. Categories and Variables for the Purposeful Selection

Categories	Variables
Agricultural Management	Technical crop management, resource use, innovations for effectiveness and sustainability
Markets	Size, location, access for diverse crops; farmers' market engagement.
Economics	Profitability, risk management, scalability, returns
Social	Cultural aspects, actor relationships, networking for adoption success
Environmental	Sustainable practices' effects on resources, resilience, and market opportunities
Policy and Governance	Government, industry, nongovernmental organization (NGO) roles via policies, incentives, collaboration

media) to match variables. DCB input refined and confirmed selection for Midwest landscape representation. This multiple-case approach selected three cases of crops that fit within corn-soybean rotations and represent ongoing diversification efforts in the region for a comprehensive understanding of diversified markets (Yin, 2017): peas, wheat, and oats.

Employing a purposive case-selection strategy enables a comprehensive but varied dataset (Saunders et al., 2009) and ensures replicability for meaningful comparisons (Yin, 2017). We selected crops fitting corn-soybean rotations to identify factors influencing success, plus opportunities and challenges for actors. Findings reveal diversified agriculture dynamics, informing strategies for sustainable and resilient globally relevant farming systems.

Data Collection

This study incorporated primary and secondary data sources. Primary data were obtained through semi-structured interviews, approved by Purdue University's IRB (approval number: IRB-2022-151), with key actors actively involved with the selected crops. Secondary data, from publicly accessible sources—websites, podcasts, blogs, and social media—complemented these insights. Secondary data were collected from spring 2022 to spring 2024 and focused on materials relevant to the selected crops and their value chains in the U.S. Midwest, as well as broader information on global market trends and contextual developments shaping diversification.

Interviewees represented four groups: farmers, industry professionals (including processors), nonprofit representatives, and agricultural cooperative members. Participants were recruited via snowball sampling, starting with industry professionals and supplemented at field days to capture diverse perspectives while acknowledging potential biases (Heckathorn, 1997; Wilson, 2014), such as participants being connected within existing networks or actively engaged in industry events, which may limit representation of less-connected voices. The sample includes uneven representation across actor types, with a stronger emphasis on farmers and upstream actors, reflecting the study's focus on production and market-entry phases. While downstream actors were not included, this delimitation aligns with the research objectives and allows for deeper analysis of early-stage value-chain dynamics.

Data collection concluded when themes and insights consistently recurred. From October 2022 to February 2024, 29 of 53 contacted individuals were interviewed in person or via Zoom. All interviews were conducted by the same researcher to ensure methodological consistency. We conducted 29 interviews with diverse actors: 22 male, 7 female. Participants spanned Indiana (13.8%), Illinois (3.4%), Iowa (34.5%), and other states (Nebraska, Michigan, Minnesota, Ohio; 48.3%). Roles included farmers (44.8%), industry professionals (34.5%), cooperative members (13.8%), and nonprofits (6.9%); case studies spanned oats (44.8%), peas (24.1%), and wheat (31%). Table 2 summarizes characteristics.

We attended three Practical Farmers of Iowa (PFI) field days. PFI, a nonprofit promoting sustainable agriculture via farmer-led research, education, and community building, primarily serves Iowa farmers but influences beyond the state.

Table 2. Descriptive Information on Interviewees

	Male (*n* = 22)	Female (*n* = 7)
Role		
Farmer	13	0
Industry	5	5
Co-op	3	1
Nonprofit organization	1	1
Case Study		
Oats	11	2
Peas	5	2
Wheat	6	3

These events enabled engagement with farmers and actors producing the selected crops, aiding interview recruitment and the understanding of stakeholder dynamics.

Data Analysis

Interviews were audio-recorded and transcribed using Transcribe*Me*![1] Transcripts were analyzed via combined deductive-inductive coding: deductive codes from the literature review (as overarching categories) and inductive codes from the data (as subcategories). Table 3 summarizes the codebook (parent codes, subcodes, descriptions, examples). All subcodes appeared across the three case stud-

Table 3. Code Structure: Parent Codes, Subcodes, Descriptions Across Cases

Parent Code	Subcode	Description
Background	Role	Stakeholders (farmers, agribusinesses, NGOs, co-ops)
	Business profile	Type, experience, production, operations
	Type of diversification	DCB project classification
Agricultural Management	Effort to produce	Planning, labor, and resources for crops
	Knowledge	Expertise in production, harvest, and sale
	Adoption rate	Implementation of new practices and technologies
	Organic certification	Processes and standards
Markets	Required infrastructure	Facilities for production, processing, and distribution
	Access to markets	Ability to reach consumers or buyers
	Market stability	Supply, demand, and pricing
	Innovation	New ideas or technologies
	Quality of products	Excellence standards
	Quantity of products	Sales volume
	Marketability	Attractiveness and sales potential
	Consumer behavior	Patterns and preferences
Sociocultural	Motivations	Cultural drivers and values
	Stakeholder ties	Sector collaborations
	Networks	Relationship webs
	Prestige	Social recognition
	Product perception	Societal and market views
Governance	Government support	Policies and programs
	NGOs support	Nongovernmental organization, civil society, and private mechanisms
	Crop insurance	Financial risk protection
Environment	Environmental effects	Soil, water, and biodiversity impacts
	Sustainable practices	Environmentally responsible production and distribution
Economic	Risk	Uncertainties and management
	Future outlook	Trends and planning
	Scalability	Growth and replication potential

[1] https://www.transcribeme.com/

ies, confirming consistency and enabling thematic pattern identification.

The coding framework was refined via inter-coder reliability (Gardner, 1995; Sebastian, 2019). Two researchers independently conducted three rounds, discussing interpretations and reconciling until Cohen's kappa ≥ 0.7 (Cohen, 1960; Gardner, 1995). Round three reached kappa = 0.80; the principal researcher then coded remaining interviews independently using the finalized framework. The lead researcher applied this framework to remaining transcripts. NVivo14 supported data analysis, with separate examination of each case study to identify primary challenges, opportunities, and success factors.

A cross-case analysis synthesized findings across the three cases, guided by the SES framework, examining interactions among actors, governance systems, resource systems, and external socio-economic and/or ecological contexts. This approach offered theory-informed interpretation of commonalities and differences, highlighting multi-level interactions and feedback shaping decisions and outcomes in diversified agricultural value chains (Miles et al., 2013; Yin, 2017). The SES-grounded comparison provided a structured multi-case framework for understanding farmer behavior and complexity of system transformation.

A thematic approach was employed to explore relationships between cases, systematically identifying, analyzing, and reporting patterns or themes within the data about drivers of success (Braun & Clarke, 2019; Byrne, 2022; Vaismoradi et al., 2013). The cross-case analysis uncovered common themes and external-influence factors shared across cases (Braun & Clarke, 2021; Cheng & Catallo, 2023), which facilitated a deeper analysis of the interconnections between actors, scalability, and adoption rates, contributing to a comprehensive understanding of the drivers of success that influence agricultural diversification.

For objective three, two researchers mapped findings onto Ostrom's (2009) general SES model (resource systems or units, governance systems, actors and users, interactions and outcomes). This mapping revealed how interactions, and their absence, enable or constrain agricultural diversification pathways through value chains.

Results and Discussion

The results are presented in two sections. First, case studies highlight opportunities, challenges, and impacts for corporations and growers in oat, pea, and wheat value chains. These systems extend crop rotations by replacing corn or soybeans in one or more growing seasons, and they illustrate how different actors navigate diversification dynamics. Second, cross-case analysis maps resource systems and units, governance systems, actors, interactions, and outcomes as complex SES across social, ecological, and political contexts, showing how policy, ecological conditions, and social capital shape decision making for resilient, sustainable production and practical Midwest diversification implications.

Overview of the Case Studies

This section presents case studies of oat, pea, and wheat markets in the U.S. Corn Belt, highlighting opportunities, challenges, and success factors for diversification.

Peas

The pea value chain presents environmental, economic, and social benefits, while facing notable challenges and opportunities. With their nitrogen-fixing capability, peas enhance soil fertility by reducing reliance on external nitrogen inputs (Maharjan et al., 2019; Stevenson & van Kessel, 1996). A farmer explained that growing peas is like "growing their own fertilizer," reducing dependency on synthetic nitrogen fertilizers while supporting their rotation systems. While soybeans also fix nitrogen, participants noted that peas are typically integrated earlier in the rotation and can provide more immediate nitrogen contributions to subsequent crops, along with shorter growing seasons that allow greater flexibility in crop sequencing. Collectively, these factors contributed to overall soil health, supporting sustainable agricultural practices.

In terms of economics, interviewees shared that peas lowered input costs, improved crop yields, and increased profitability. The rising demand for plant-based products derived from peas (Stewart et al., 2020) is opening new revenue streams. A corporate interviewee commented:

> [Growing peas] was challenging at first because it's not something that [farmers] commonly used, and it was something that if they did use, it was for a cover crop, so they weren't cashing in on it. It was something that they would plant in order to help their yields or, forward-thinking farmers. So, when we came to market with peas and tried to encourage farmers to grow peas, they looked at us a little crazy. But we luckily had a market proven to buy it.

PURIS Foods, a processor that contracts farmers to produce peas, has leveraged the growing pea protein market for financial growth and sustainability goals. A U.S. leader in pea protein for plant-based foods, PURIS operates across grains, protein, and holdings (as described by a company member), focusing on food technology and product development in holdings (e.g., AcreMade brand). Actors noted that PURIS Foods' strategy met consumer demand via product innovation and strong partnerships with farmers and industry actors. For example, a corporate interviewees shared:

> There was a giant gap in the marketplace. No one could figure out the protein piece to work in coffee creamers or naked juices… (...) And we've been able to solve that …We've had huge interest from some of our partners in launching that.

Socially, interviewees noted peas in rotations improve food security and livelihoods via higher productivity and profitability. Reduced reliance on synthetic nitrogen contributes to improving community health and environmental quality. While peas are managed similarly to soybeans in many systems, participants noted key differences such as lower water requirements, offering potential water conservation benefits. These characteristics support resource-efficient production and contribute to the long-term sustainability of farming systems. A grain program staff member working with 500+ farmers stated:

> I think for us, it's to introduce a crop, in this case yellow field peas, to producers, not only to give them a market, which is important, and have it been successful on their farm, but I think the thing that gets lost in all of this is the sustainability piece to it. Because at the end of the day, all of the land that's currently farmed, the longer that we can farm it, the longer that we're going to be able to provide protein food, global food supply, all of those things…[peas] need a lot less water to prosper. Typically, soybeans are somewhere around 8–10 in of rain or irrigation per year, which is optimal. Peas can thrive on as low as 2 in of water per year.

A farmer noted how peas improve food security and livelihoods because they were easily introduced into existing crop rotation:

> Peas were a different type of crop that fit into a rotation that lets you plant peas, and then you could plant winter wheat after the peas that fall after you harvest them in July.

Despite these advantages, the pea value chain faces significant barriers. Corporations encountered farmers' skepticism about profitability and limited market demand, hindering scalability. Inadequate infrastructure and unpredictable yields further complicated expansion. Since few farmers grow peas, supply shortages and quality inconsistencies constrained companies' ability to market and sell pea-based products. As buyers noted:

> The most challenging part is just knowing how much—again, from our perspective as a buyer of peas, is not knowing how much we'll be able to grow, not knowing what the supply and, really, more importantly, the cost of that supply will be that year.

Producers faced persistent financial, technical, and logistical barriers to adopting diversified cropping systems. High transition costs, limited technical knowledge, and inadequate infrastructure remain key barriers to scaling pea cultivation. As some challenges persist, companies like PURIS indicated they are exploring international trials to meet growing demand. One member commented:

> We are exploring some other world areas like Latin Am, trying to grow peas down there and see if we can partner with some of those growing plant-based businesses across Latin America and then portions of Europe.

The expansion of plant-based protein markets presents significant opportunities for the pea industry. However, a growing reliance on international trials can challenge U.S. farmers because firms consider sourcing and testing alternatives in other regions, when domestic supply cannot fully meet industry requirements. This dynamic reinforces persistent barriers to diversification for Midwest farmers (Roesch-McNally et al., 2018), who may be sidelined as companies optimize varieties, contracts, and supply chains around foreign production systems rather than U.S.-based systems. Strategic innovation in pea-based products, supported by collaboration between corporations and domestic producers, and by robust policy and institutional frameworks, will be essential to open new markets, drive economic growth, and advance sustainable agriculture while enhancing regional and global food security.

Wheat

The wheat value chain reveals complex environmental, economic, and social dynamics with key challenges and opportunities. Environmentally, farmers' reduced tillage and use of cover crops and rotations improved soil health and biodiversity, interviewees noted. Stakeholders stressed the practices' role in ecological balance and wheat cultivation viability. Wheat rotations boost agrobiodiversity, alter field operations, disrupt pest-disease cycles, cut chemical inputs, enhance ecosystem resilience, and support soil organisms, insects, and wildlife for broader system health.

Wheat's role is place-specific: in Indiana, it is a double crop in the south and a cover crop in the north. Extension experts noted winter wheat typically precedes soybeans, but only where climate allows timely planting or harvest. This underscores distinguishing wheat's perceived ecological benefits from its actual use across geographies and management systems.

Economically, cooperatives and NGO collaboration improved market access and efficiency. Infrastructure investments (e.g., nearby mills), soil health, sustainability programs, and conservation incentives enhanced supply chains, created producer opportunities, and supported long-term value-chain stability. As one interviewee noted:

> We will be building a new facility with three milling units…With this expansion, we would project an additional demand of at least nine million bushels needed per year. We hope to see local farmers growing more wheat because that will certainly contribute to our mutual success, theirs and ours.

Economically, this directly impacts farmers, as one noted:

> Lots of guys who have made this a part of their rotation in some way, and economically speaking, if you can do it successfully, it's an economic home run.

Socially, strong stakeholder relationships improved food security by linking locally grown wheat to regional markets, providing stable farmer incomes, and increasing access to high-quality wheat. These connections support premium prices for sustainable production and encourage continued engagement in diversified practices, enhancing community resilience to market and environmental changes. As one interviewee highlighted:

> I think the biggest opportunity is…being able to find companies that want to pay a premium for our locally grown wheat in this area. And being able to use that sustainably, and just finding that market to give our customers extra incentives to grow wheat, raise wheat, and just have good quality.

An example of this approach is an expansion by Star of the West Milling Company, investing in a new mill in Indiana. Replicating its successful Ohio partnership with Campbell's (Schroeder, 2022; Waters, 2022), which supported sustainable agricultural practices through technical assistance, financial incentives, and infrastructure investments,

improving cover cropping adoption, market access, and long-term productivity. Interviewees noted that these partnerships strengthened the connection between farmers and brands such as Goldfish crackers, fostering pride and purpose among growers:

> We love to tell the story that the Goldfish crackers are made with Star of the West wheat. So, farmers love to grow things that actually turn into food…A lot of the 'I' states are growing corn that goes into ethanol and soybeans that goes into something else. They're not actually growing food. So, introducing growers to the food customers that they're growing for and showing them the brands and sharing some of that product with them, even if it's a box of cereal, has all been really good for us.

While this perspective emphasizes branding and consumer connection, co-ops also highlighted the benefits of these partnerships in connecting farmers to broader markets. One member of a co-op stated:

> The ultimate goal is we feel like there's a lot of value that we can deliver to our customers by helping them connect to that global food supply chain that they would not be able to do as a producer on their own, which is really the purpose of the program.

Co-ops played a key role in facilitating these connections by aggregating grain, coordinating logistics, managing contracts with end-users, and ensuring compliance with sustainability standards—services difficult for individual farmers to manage independently. Co-ops helped scale farmers' reach and integrate them into broader markets. Collaborations between partners contributed to a more resilient wheat value chain that balances environmental, economic, and social considerations.

Wheat value chains face barriers: corporations struggle to align sustainable sourcing, milling, and distribution with existing supply chains; farmers face financial, technical, and logistical issues adopting diversified crops. Collaborative models, farmer education, and support for policies and incentives are critical to overcome resistance, promote innovation, and enable sustainable wheat adoption. Financial incentives are crucial for small-grain adoption (Asprooth et al., 2023). As one interviewee noted:

> This challenge could be addressed in general by financial incentives that helped the growers add wheat crop to their farm. The other thing that we've tried to work on with, I thought about this as a policy…If we could receive the funding for a cover crop and also be harvested and sold as a food crop, that would be amazing because it's doing both purposes. And because it's not funded as nicely as corn, that would be one way that you could put it back financially into a better playing field.

Despite sustainability, financial, technical, and logistical challenges, the wheat value chain offers market opportunities. Cooperative and NGO collaboration enhances sustainability and efficiency, and creates opportunities; promoting collaborative models and sustainability programs aligned with market and environmental goals drives growth. Technical assistance to farmers, financial incentives to farmers and buyers, and processor infrastructure investments support sustainable practices and market access, as in Star of the West-Campbell's partnership and in small grains research (Asprooth et al., 2023; Sustainable Food Lab, 2023).

The wheat case study indicates that advancing sustainability initiatives and strengthening partnerships addresses challenges and seizes opportunities. Coordinated corporate, producer, and policymaker efforts—backed by financial incentives and/or enabling policies—enable wheat's significant contribution to regional and global sustainable agriculture and food security.

Oats

The reintegration of oats into production has generated economic and social impacts, alongside barriers and opportunities. Economically, the rising demand for oat-based products is shifting oat production from centering on animal feed to human consumption (Marshall et al., 2013; Mel &

Malalgoda, 2022; Yang et al., 2023). Companies such as Oatly have capitalized on this trend, seeking to source directly from U.S. growers, which enhances both market potential and producer resilience. As one pilot project farmer shared:

> It seems like the market or the business is growing with companies like Oatly…The pilot project we work with them was for them to source oats directly from the farm versus right now they source oats from like Grain Millers or somebody like that. It's a drastic change to their supply chain models, so that's why they were doing a pilot project with it.

Socially, collaboration between agricultural players such as Grain Millers, PFI, and oat growers fostered community benefits and supported economic well-being of the agricultural community in the region. These partnerships underscore the importance of collective efforts in promoting sustainable agricultural practices and economic development. Development of field days and webinars served as a collaborative knowledge-sharing approach, ensuring that stakeholders were updated on evolving market dynamics. A staff member of PFI commented:

> Field days are typically more about production, but we'll often have people come from [industries], from places and talk about their markets or what they're seeing or how they're buying or how they're using small grains. So, we do that in mostly a webinar-type format.

Oat production faces challenges: corporations deal with *Fusarium* contamination; farmers meet strict food-grade standards via careful management and investments in cleaning, sorting, and storage infrastructure. Limited local processing and the historically feed-oat focus have deprived market access; potential rejection or financial losses discourage farmer adoption.

These challenges remain partially addressed, posing barriers for farmers, especially small-scale producers, in meeting food-grade quality standards and regulations (Costantino et al., 2025). Many struggled with consistent grain quality, testing, and documentation for higher-value markets, limiting demand benefits. Meanwhile, industry opportunities grow via rising oat-product interest from health trends (Marques et al., 2026), requiring processor-farmer-agri-food collaborations. Organizations such as PFI are supporting sustainable practices and networks enabling oats in corn-soybean systems. As a Grain Millers member shared:

> We've tried to the best of our ability to provide agronomic support to growers that are wanting to add oats into the rotation…it was kind of a bit of a lost art if you want to say that. Growing oats or growing small grains for a lot of these corn/soybean growers. Now a lot of that has started to come back.

The oats case study demonstrates that emphasizing sustainability, market development, and overcoming logistical and policy barriers are essential strategies for capitalizing on the opportunities in the oat market, and thus enhancing its role in diversified agriculture in the Midwest and overall impacting the global food supply chain.

Cross-Case Analysis

The oats, peas, and wheat SES value chains in the U.S. Midwest spanned cultivation, processing, and distribution. Farmers initiated production within dominant corn-soybean rotations; processors and distributors handled post-harvest and market delivery. Cooperatives, NGOs, and Extension services provided technical support and innovation; government agencies shaped practices via incentivizing policies. Together, the actors influenced efficiency, quality, and sustainability. Understanding interactions among farmer decision making, institutional support, biophysical and market conditions—core SES components (McGinnis & Ostrom, 2014; Ostrom, 2009; Thomas Travaille et al., 2019)—is essential for explaining how diversification strategies emerge and evolve.

As a complex adaptive system, the value chain reflected dynamic interactions among resources, governance, actors, and broader political, social, economic, and ecosystem contexts. For instance, adoption of new crops was driven not only by markets and policies but also by technical assistance

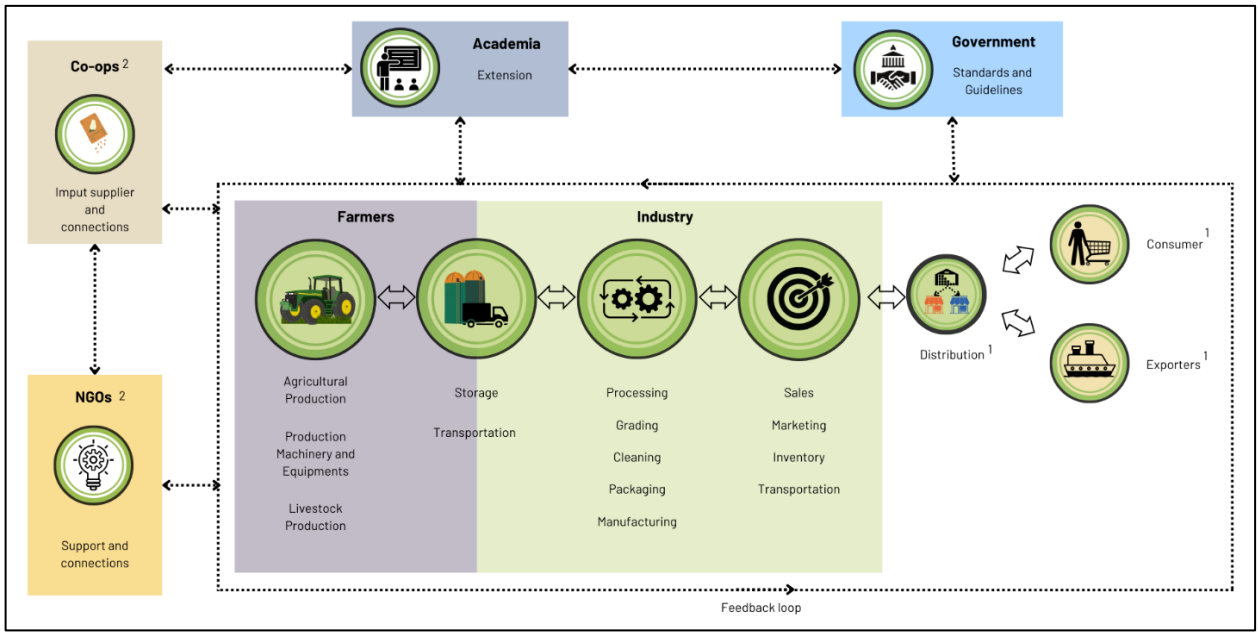
and social networks. Strengthening sustainability thus requires recognizing these interdependencies and advancing collaborative, cross-sector strategies (Figure 1).

Value-chain SES results highlight multi-level interactions. At the micro-level, farmers' beliefs, experiences, relationships, and risk perceptions drove crop adoption. At the meso-level, cooperatives, Extension services, and policies reduced barriers and contributed to trust. At the macro-level of interactions, market dynamics, national policies, and institutional frameworks (present or absent) shaped outcomes. The three interdependent levels demonstrate that interventions cascade across scales, thus emphasizing the role of adaptive, resilient strategies for sustainable diversification.

Figure 2 maps value-chain SES results to the SES framework for pea, oats, and wheat cases. In the value-chain SES, resource systems, governance systems, resource units, and actors interacted to produce outcomes for actors. Interactions affected farmer decision making, knowledge co-production, farmer-Extension collaboration, and supply-chain coordination, impacting social, ecological, and political settings. Outcomes included improved system sustainability, increased market access, and farmer innovation—all supporting ecosystem settings via improved soil health and biodiversity restoration. Active interactions enabled diversified farming adoption; non-active or weak interactions (e.g., pea production's limited local sourcing, which prompted international alternatives over local collaboration) constrained diversification, leading to maladaptation that reinforced unsustainable systems.

Figure 2 shows how agricultural diversification is shaped by market forces, actor relationships, and interactions among governance (e.g., certification standards, subsidies, conservation programs), actors (farmers, cooperatives, industry, Extension, NGOs), resource units (oats, peas, wheat), and resource systems (field conditions, crop rotations, climate). It includes broader social, economic, and political settings, such as commodity price trends,

Figure 1. Cross-case Analysis of Oats, Peas, and Wheat Value Chain



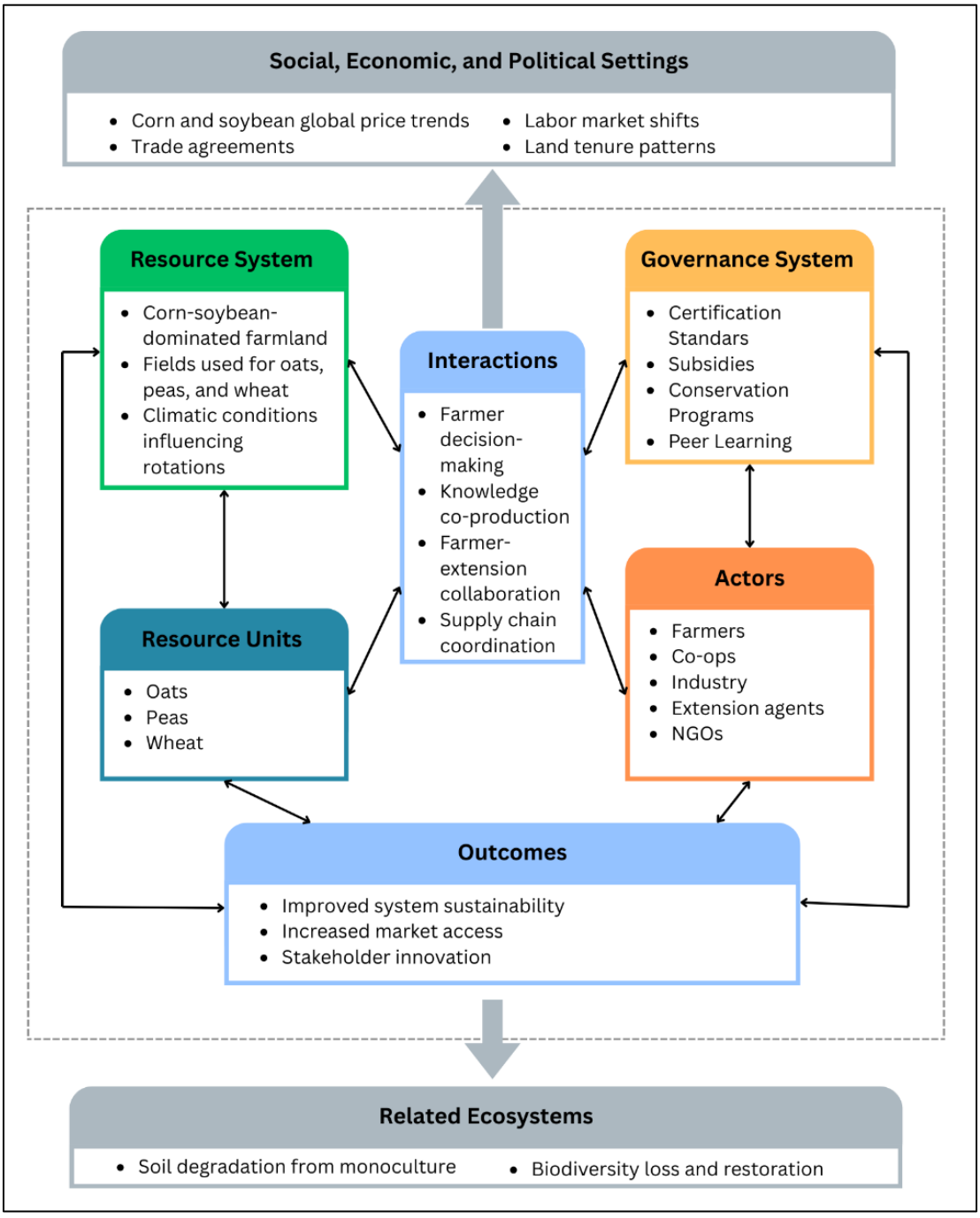
Note 1. While direct stakeholder perspectives were not obtained, the insights presented here are informed by comprehensive literature reviews and industry expertise.

Note 2. While the oats and wheat value chains provided ample evidence of connections and networking facilitated by cooperatives (Co-ops) and non-governmental organizations (NGOs), evidence is lacking regarding these supports in the pea case study. Based on the available data, this absence appears to reflect a structural characteristic of the pea value chain, particularly its more centralized, industry-driven organization, rather than solely a data limitation.

labor shifts, and land tenure, influencing system behavior over time. Figure 2 incorporates ecological feedback from monocultures (soil degradation, biodiversity loss), situating value chains in their biophysical context.

These governance structures and platforms, including Agricultural Innovation Platforms (e.g., Extension field days, commodity group meetings, farmers' networks), can enable or constrain innovation by shaping how actors interact, exchange

Figure 2. A Social-Ecological Systems (SES) Perspective on Oats, Peas, and Wheat Value Chains: Mapping Findings to the SES Framework



knowledge, and access resources (de Boon et al., 2022; Turyahikayo et al., 2017). Incorporating these institutional and relational dimensions provides insight into how farmer decisions and broader agricultural diversification trajectories are co-shaped within multi-layered governance contexts (Turyahikayo et al., 2017).

The mapping in Figure 2 enhances value-chain analysis' interpretive power by revealing underlying structures and feedback that condition innovation, adoption, and sustainability. It fosters holistic understanding of farmer decision making and landscape change (or lack thereof), reinforcing multi-scalar, adaptive strategies for resilient agricultural systems. The discussion further details cross-case value-chain SES interactions and outcomes.

Value-Chain SES Interactions

A crucial SES theme emerging from the cases was collaboration across system actors to coordinate value chains and integrate farmers more effectively. At the micro-level, adoption of alternative crops such as oats, peas, and wheat is influenced by actors' prior experiences, perceptions of risk, personal goals, and the quality of their relationships. Consistent with prior research demonstrating that farmers' decisions in the U.S. Midwest are shaped by stakeholder interactions and their previous experiences (Traldi et al., 2024), findings show strategic partnerships and networks enhance sustainability, infrastructure, and product differentiation. Weak relationships (e.g., in the pea case study) limited local diversification as well as farmer incorporation into commodity markets. Fruitful collaborations enabled transitions from commodity to higher-value food-grade markets via direct buyer ties, supply chain coordination, and technical and financial assistance. As an interviewee suggested:

> I think that's the biggest opportunity if farmers could move from growing commodities to growing food and a more direct link with consumers and the people eating the food than a big conglomerate in the middle. And I think consumer taste will evolve where they want to know where their food is coming from.

Farmer-Extension collaborations connected farmers to diversified cropping systems and equipment. University Extension provided crucial technical support, with R&D funding for equipment tailored to diversified crops (Cutforth et al., 2001). Increased storage capacity addressed growing grain storage needs. Extension training and education aided farmers' transitions to new equipment and cropping systems. As a farmer explained:

> [We] used to have yellow pea field days [organized by university Extension] because there was lots of research going on in western half of the state with yellow peas. It seems like they've pretty much stopped them. I'm thinking because of the change of administration or just ran out of research dollars…I'm guessing a lot of it has to do with the commodity prices have changed. Corn and soybeans are the thing to grow now because the prices are better for those now.

In addition to collaboration helping farmers to integrate into the value-chain SES, collaborative interactions impacted farmer decision making, a central process within the SES that links individual agency to broader system dynamics. Farmer adoption of oats, peas, or wheat was not made in isolation but was shaped by biophysical, social, and institutional factors: ecological conditions (soil health, climate suitability), market incentives, risk perceptions, and personal and community values. Interviewees noted diversification often came from perceived benefits such as improved soil fertility, reduced input dependence, or conservation alignment—but faced constraints from market viability uncertainties, input availability, and limited policy support. These dynamics reflect SES action situations, in which decisions emerge from interactions among actors (farmers), governance (programs and/or policies), and ecological contexts (fields, climate, pests). As one farmer explained:

> Lots of guys who have made this a part of their rotation in some way, and economically speaking, if you can do it successfully, it's an economic home run. And then on top of that, soil health-wise, it's a lot better than just raising

> just beans or just wheat that year. So, a lot of stuff, I guess, but diversifying would be the big takeaway.

Knowledge co-production—a key SES interaction—shaped adaptive, informed value- chain systems. It involved shared knowledge development and exchange among farmers, buyers, agronomists, NGOs, and Extension professionals via sustained platforms such as field days, farmer networks, and buyer-producer forums. These aligned production with market needs and improved on-farm decisions, and built cross-chain trust. Unlike one-way technical transfer, they created feedback loops merging experiential, scientific, and market knowledge for innovation and joint problem-solving. As one PFI member described:

> Field days are typically more about production, but we'll often have people come from [Industries], and talk about their markets or what they're seeing or how they're buying or how they're using small grains.

These interactions—spanning supply-chain coordination, farmer-Extension collaboration, farmer decision making, and knowledge co-production—underscore the dynamic and interconnected nature of the value-chain SES. Together, they demonstrate how multi-actor engagement fosters adaptability, supports transitions to diversified markets, and strengthens the resilience of farming systems. At the meso-level, these interactions facilitate trust and shared learning so that institutional support emerges, reducing transaction costs, enhancing technical capacity, and enabling adaptive responses to ecological variability and market uncertainty (Berkes, 2017; Lebel et al., 2006). By understanding and enhancing these interactions, stakeholders can more effectively co-create sustainable and inclusive agricultural value chains.

Finally, at the macro-level, resource systems—agricultural landscapes and the embedded commodity value chains—are shaped by external drivers like trade policy, input costs, and climate variability. For example, fluctuating corn and soybean prices, interlinked globally, create feedback loops influencing farmer decisions and market behavior. These uncontrollable macroeconomic signals cascade across the SES, underscoring the role of multi-scalar interactions in outcomes. Recognizing these dynamics is essential for resilient, scalable, context-responsive interventions prioritizing systems-based approaches over individual practices (Morris et al., 2021).

Value-Chain SES Outcomes

Our value-chain SES analysis shows how diversified crop systems—via collaboration, governance, and evolving markets—enabled alternative crop markets in the U.S. Midwest. Outcomes fostered systemic transformation beyond individual benefits, as new relationships, trust, and shared sustainability goals emerged.

A key outcome across all crop cases is enhanced system sustainability. Diversifying with oats, peas, and wheat strengthened ecological resilience by improving soil health, reducing input dependence, and increasing biodiversity. Stakeholders emphasized that this ecological feedback created more adaptive farming systems, better equipped to handle climate and market fluctuations:

> In the US is oat's opportunity to impact crop rotations, success for growers. I mean, there's been tons of cases were adding oats to your rotation for growers helps in a whole variety of pest reduction, weed suppression, changes a lot of those pest cycles for improvement, both in your corn and soybeans, which might be your more significant cash crops.

Case studies also show increased market access by repositioning oats, peas, and wheat from low-value commodities to food-grade crops (Cargill, 2018; Waters, 2022; Watrous, 2021). Interviewees noted that transition to higher quality crops opened premium markets valuing sustainability, traceability, and quality. These shifts arose from buyer demand, farmer readiness, and supporting infrastructure enabling value differentiation.

Strategic buyer-producer relationships shaped these markets. Weak ties, as in peas—where buyers couldn't source locally and pursued international options instead of enhancing local supply—constrained diversification by relying on non-local

sources (Roesch-McNally et al., 2018), an outcome consistent with the SES literature (Bodin & Crona, 2009; Jordan et al., 2023). In contrast, infrastructure investments, direct contracting, and certification programs lowered entry barriers and built long-term trust. As one actor explained:

> I think the biggest opportunity is being able to find companies that want to pay a premium for our locally grown wheat in this area. And being able to use that sustainably, and just finding that market to give our customers extra incentives to grow wheat, raise wheat, and just have good quality.

These cases show value chains evolving via mutual economic and environmental value recognition, creating feedback loops incentivizing diversification. Collaboration and innovation fostered premium market access, establishing durable place-based markets. Alternative crop adoption in corn-soybean systems requires multi-level value chain and incentive restructuring (Meynard et al., 2018; Traldi et al., 2024), including development of social infrastructure (trusted networks, advisory services), physical infrastructure (regional processing and storage), and policy frameworks supporting ecological intensification and market diversification. The SES framework reveals how subsystem interactions drive system adaptability and sustainability.

Finally, in the process of transitioning toward new markets, actors engaged in continuous innovation to navigate agronomic and economic uncertainties, which included adapting production techniques for emerging crops, experimenting with crop rotations, and developing on-farm storage or handling capabilities. As new markets offered uncertain yet promising returns, farmers played an important role in testing the viability of crops. One interviewee reflected on this adaptability:

> The soy business is very mature. It's been around for a really long time. It's not a new innovative idea by any means…And so, they sidetracked and started to dabble with the peas and see if they could create a pea protein.

This example illustrates how innovation is not only technical but strategic—shifting attention to underutilized crops and niche markets as an avenue for differentiation and resilience. Innovation became a key mechanism through which stakeholders actively participated in shaping and expanding diversified market systems.

Together, improved system sustainability, increased market access, and stakeholder innovation reveal how diversified crop markets emerge via gradual experimentation, relationship-building, and structural support. Supportive institutional and relational infrastructures—Extension programs, strategic partnerships, private sector alliances, farmer networks—provided the backbone, offering knowledge, resources, and trust to reduce uncertainty and to align actors. Thus, diversification represents not just agronomic and economic shifts but socio-institutional achievements rooted in collaboration, responsiveness, and shared vision.

Conclusions

This study reveals system dynamics in U.S. Corn Belt diversification markets, showing how stakeholder collaboration, social-physical infrastructure, market access, and sustainable practices interact to drive farm and landscape transitions. The SES framework demonstrates how actors embedded in multi-level social, institutional, and environmental networks guide decision making and enable or constrain local diversification.

Cross-case analysis confirms that value chains are complex adaptive systems where sustainability, market access, and farmer innovation emerge from processor-buyer-researcher-farmer interactions, supported by infrastructure and governance. Weak relationships between groups and lack of enabling policies constrain these outcomes, reinforcing unsustainable systems and limiting local diversification. These findings are crucial for informing efforts to advance agricultural diversification and maintain resilient markets that support farmers and buyers. By using an SES approach as opposed to a traditional value-chain approach to framing these findings, this research highlights how social and ecological factors can limit or enable economic value chains and related production (Loomis et al., 2026; Pradhan et al., 2022), emphasizing the interconnectedness and interdependence of economic,

political, social, and ecological conditions. Several limitations should be considered: the study focused on a specific set of crops (oats, peas, and wheat) in select regions, relied primarily on interviews, and may not capture long-term trends or perspectives of conventional farmers not engaged in diversification. Despite limitations, this study advances understanding of collaboration and sustainability in agricultural value chains and forms part of the larger Diverse Corn Belt project,[2] which addresses these via complementary investigations.

Future research should connect micro-level farmer decisions with meso-level collaborations—such as cooperatives, nonprofit alliances, and enabling policies—and macro-level market dynamics to better understand how diversified value chains are constructed, scaled, and sustained. Through examining these interactions, diversification can be seen not merely as a crop substitution but as a socio-ecological reorganization, where micro-level decisions and macro-level trends converge to generate new pathways for resilient agricultural systems in the U.S. Corn Belt and beyond. Future policy and practitioner efforts can aid in overcoming persisting challenges like financial and technical limitations related to the adoption of diversified products in farming systems. Establishing new or redirecting existing financial incentives (e.g., Farm Bill conservation programs) to prioritize the production of diversified products is necessary to address farmers' financial constraints, enable product adoption, and support a robust product value chain. Technical assistance provided by Extension services, NGOs, industry, and other groups can be geared towards filling knowledge gaps around producing diversified products and further enabling their adoption by farmers.

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Toward resilient agrifood institutions: Evaluating farmer corporations in the context of shallot value chains in Indonesia

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Abstract

Building resilient horticultural systems is critical in the face of climate variability, market instability, and institutional fragmentation. In Indonesia, farmer corporations have emerged as institutional arrangements intended to strengthen coordination among smallholder farmers and improve agribusiness development. However, limited attention has been given to how farmer corporations operate within the horticultural value chain and contribute to local resilience. This study examines the role of farmer corporations in strengthening the shallot value chain in Majalengka Regency, West Java, Indonesia. This analysis focused on institutional coordination, governance mechanisms, and development priorities within the shallot value chain. The evidence shows that farmer corporations can strengthen resilience by enhancing institutional coordination, collective bargaining, market access,

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production support, and adaptive capacity in the face of climate and market uncertainty. Institutional integration among farmer groups, farmer group associations, cooperatives, government agencies, and private-sector actors was found to be important for strengthening shallot agribusiness governance and promoting long-term horticultural development. This study contributes to the literature by positioning farmer corporations as farmer-based institutional integration mechanisms, rather than conventional investor-driven corporations. Our results emphasize the need for institutional governance customized to local conditions and collaborative value chain coordination in developing resilient horticultural systems in Indonesia and other agribusiness settings.

Keywords
farmer corporations, institutional integration, collective action, shallot value chains, agrifood resilience, Indonesia

Introduction and Literature Review

Building resilient agribusiness systems is becoming increasingly critical in the face of climate variability, market instability, and stress on rural livelihoods (Béné et al., 2016). Resilient agribusiness systems are expected to strengthen local communities' adaptation capacity in the face of economic and environmental uncertainty, rather than just maintaining

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food production and distribution (Hinrichs, 2014; Tendall et al., 2015). Horticultural systems face unique resilience problems because the output is heavily reliant on seasonal variables, input availability, market fluctuations, and postharvest management. Consequently, strengthening institutional coordination among farmers and other stakeholders is crucial for the long-term development of the horticulture sector.

Farmer organizations play an important role in improving coordination across the agricultural value chains. Previous studies have demonstrated that farmer groups, cooperatives, and collective institutions can increase access to agricultural inputs, extension services, financing, and markets while boosting bargaining power and lowering transaction costs (Rout et al., 2023). Institutional collaboration also promotes information sharing, technological adoption, and collective responses to production and market risks (Folke, 2016; Pani et al., 2022). Thorsøe et al. (2020) emphasized the importance of institutional integration in horticultural systems, where farmers often operate on a small scale and experience substantial price fluctuations.

In Indonesia, institutional strengthening in agriculture is increasingly centered on forming farmer corporations. A farmer corporation differs from the conventional definition of a corporation, which is an investor-driven agribusiness. According to Indonesian agricultural policy, a farmer corporation is a legally incorporated collective business entity formed by combining farmer groups, farmer group associations, cooperatives, and other local agribusiness actors to improve value addition, competitiveness, and farmer welfare (Anggreany, 2025; Suharti et al., 2025). These institutions are intended to manage production, finance, input distribution, processing, and marketing operations within a farmer-centered governance structure (Safitri et al., 2024; Susanti, 2024). This system is intended to increase smallholder farmers' collective negotiating power, operational efficiency, and involvement in larger agricultural markets (Jamaludin et al., 2025).

In practice, farmer groups serve as local production units that facilitate extension operations, irrigation coordination, and communication among farmers. Farmer group associations organize activities among farmer groups at the village or subdistrict level, acting as liaisons between farmers and government initiatives. Cooperatives provide a wider range of economic services, such as financing, input procurement, and group marketing. Farmer corporations broaden these functions by incorporating upstream and downstream agricultural operations into larger-scale institutional and market coordination systems (Suharti et al., 2025). Farmer corporations do not replace current farmer organizations; rather, they serve as institutional integration mechanisms that connect various farmer-based organizations within a coordinated value chain framework (Anggreany et al., 2026). The operational structure of farmer corporations in Indonesia's horticultural system is illustrated in Figure 1.

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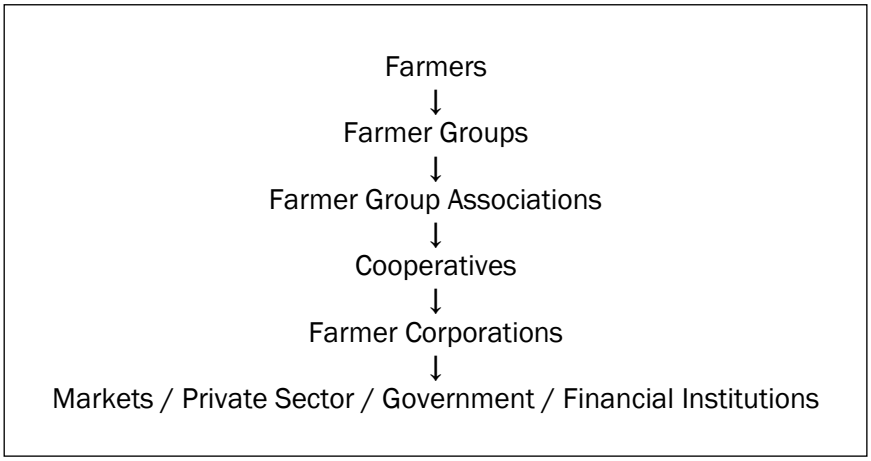
Figure 1. Operational Structure of Farmer Corporations in the Indonesian Horticultural System



Although policy support for farmer corporations in Indonesia is growing, empirical studies examining the contribution of institutional arrangements to resilient horticultural systems are limited. Existing studies have largely focused on cooperatives, farmer participation, or technical aspects of agricultural production (Azka et al., 2019; Adinugraha et al., 2025; Usna et al., 2025; Alatas et al., 2026), while insufficient attention has been paid to operational integration among farmer institutions and their role in strengthening adaptive capacity within the horticultural value chain. Consequently, evidence remains limited regarding how farmer corporations function as institutional integration mechanisms that enhance resilience within horticultural value chains. In particular, studies examining how farmer corporations function as governance mechanisms embedded in local contexts that link farmer organizations, market coordination, and institutional support under conditions of climate and market uncertainty are limited.

The shallot value chain serves as an ideal case study for examining these issues. Shallots are one of Indonesia's strategic horticultural commodities and make a significant contribution to rural income and the regional food system. However, the shallot value chain remains highly vulnerable to price fluctuations, pest and disease outbreaks, climate variability, limited access to quality inputs, and a fragmented marketing system (Nisa & Amirah, 2025; Cahyani et al., 2026). These conditions require stronger institutional coordination to support production stability, market access, and risk management. In Majalengka Regency, West Java, the shallot value chain increasingly involves farmer-based institutional collaboration through farmer groups, cooperatives, and emerging farmer corporations.

This study examines the role of farmer corporations as institutional mechanisms for strengthening resilience within the shallot value chain in Majalengka, Indonesia. It analyzes institutional roles, farmer perceptions, and strategic priorities related to the development of the shallot value chain through integrated farmer-based institutions. By positioning farmer corporations as a model of institutional integration rooted in the local context rather than as conventional commercial corporations, this study contributes to the broader literature on resilient agribusiness governance within horticultural systems.

Applied Research Methods

Research Site

The study was conducted in the subdistricts of Argapura and Cingambul, Majalengka Regency, West Java, Indonesia, from June to August of 2024. The study area is among the main shallot-producing regions in Majalengka and represents diverse agroecological conditions and agricultural systems related to the production of shallots. The shallot value chain plays a vital role in the livelihoods of local rural communities and in the development of horticulture at the regional level.

Data Collections

This study combines farmer surveys, stakeholder discussions, institutional interviews, and field observations to examine the institutional conditions and development of farmer-corporation-based shallot value chain. Data were collected from shallot farmers, farmer organizations, government representatives, researchers, and private-sector stake-

holders involved in the development of the shallot value chain in Majalengka. A summary of the respondents and institutional stakeholders is presented in Table 1.

Table 1. Summary of Respondents and Institutional Stakeholders

Stakeholder	Role
Farmers	Production activities
Farmer groups	Local coordination
Farmer group associations	Intergroup coordination
Cooperatives	Financing and marketing
Government agencies	Policy support
Researchers/universities	Technology and extension

The farmer survey was conducted through face-to-face interviews using a structured questionnaire with 127 shallot farmers selected from Argapura and Cingambul. This survey explored farming conditions, institutional participation, production constraints, market conditions, and farmers' perceptions of the role of farmer organizations in the shallot value chain.

Stakeholder discussions and institutional interviews were conducted with representatives of farmer groups, farmer group associations, cooperatives, local government agencies, universities, researchers, and private sector actors in the study area. The discussions focused on institutional coordination, market challenges, policy support, and strategic priorities to strengthen the development of the shallot value chain through the establishment of farmer corporations. Field observations were conducted to understand local agricultural practices, institutional activities, and production conditions.

Data Analysis

The analysis focused on institutional roles, farmer perceptions, and strategic priorities related to developing the shallot value chain. A descriptive analysis was used to examine the farmer characteristics and institutional conditions. Farmers' perceptions of the shallot value chain and institutional performance were evaluated using a response scale and interpreted into general perception categories (Appendix A).

A strategic analysis was conducted using a SWOT framework to identify the institutional strengths, weaknesses, opportunities, and threats related to the development of farmer-corporate-based shallot value chains in the region. This analysis was developed through stakeholder assessments and cross-factor evaluations to formulate institutional development priorities and operational recommendations aimed at strengthening a resilient shallot value chain in Majalengka (Appendix B).

Results and Discussion

This section presents and discusses the institutional conditions of shallot farming, the operational roles of farmer-based institutions, and the role of farmer corporations in strengthening the value chain's resilience. It then considers the strategic priorities for improving institutional integration and supporting resilient shallot value chain development in the study area.

Institutional Conditions in Shallot Farming

The shallot value chain in Majalengka is dominated by small-scale farming systems that remain heavily reliant on family labor, local production networks, and seasonal market conditions (Appendix C). Despite the economic importance of shallot cultivation, farmers continue to face significant production and marketing challenges. Climate variability, pest and disease outbreaks, price fluctuations, limited access to certified seeds, and dependence on local traders are the major obstacles that affect production stability and income security. Similar challenges have been reported across the horticultural value chain in Indonesia, where production risks and a fragmented market structure often limit farmers' ability to respond effectively to market and environmental shocks (Widadie et al., 2021). Dependence on informal marketing arrangements also weakens farmers' bargaining positions because traders often determine prices and control short-term financing mechanisms (Anggreany et al., 2026). These conditions indicate that the development of resilient shallot value chains requires stronger institutional coordination, not merely production activities at the farmer level. Institutional support is needed not only to improve production efficiency, but also to strengthen market coordina-

tion, collective bargaining, access to innovation, and risk management amid climate and market uncertainties. The main challenges in the institutional framework and shallot value chain are summarized in Table 2.

Table 2. Major Institutional and Production Challenges in the Shallot Value Chain

Challenge	Institutional implication
Climate variability	Production instability
Price fluctuation	Weak bargaining power
Limited certified seed	Productivity constraints
Pest and diseases outbreaks	Production risk
Market dependence	Vulnerability to intermediaries

Farmer Institutions and Operational Coordination

Farmer organizations play distinct, yet interrelated, roles in supporting the shallot value chain in Majalengka. Farmer groups primarily function as local production units that facilitate extension activities, irrigation management, communication among farmers, and access to agricultural assistance programs. The associations of farmer groups provide broader coordination among farmer groups and strengthen communication between farmers and government agencies. These organizational forms serve as vital mechanisms for collective action, facilitating information exchange, coordination, and participation in agricultural development programs (Ahmad et al., 2024; Kartika et al., 2026). Cooperatives function as economic institutions that support financing, input procurement, collective marketing, and production. Cooperatives also strengthen collective action by organizing transactions and reducing individual dependence on intermediaries. Previous studies have shown that cooperatives can improve farmers' access to inputs, financing, and markets, while reducing transaction costs through collective organization (Dong et al., 2019; Gava et al., 2021; Qiu et al., 2024; Kale et al., 2025). Farmers' perceptions of farmer organization performance and their preferences regarding institutions in the corporate-based shallot value chain are presented in Appendix D.

Although these institutions contribute to local agribusiness activities, coordination among them remains limited, particularly in technology dissemination, financing access, agricultural insurance, and market integration. A lack of coordination among supporting institutions often hinders innovation diffusion, market integration, and the expansion of collective agribusiness initiatives (Widadie et al., 2022). These challenges limit the effectiveness of local institutions in supporting adaptive and competitive horticultural systems. Figure 2 illustrates the institutional coordination within the shallot value chain.

Our results suggest that institutional differentiation alone is insufficient to strengthen the resilience. The effectiveness of farmers' organizations depends on their ability to coordinate complementary functions in the areas of production, financing,

Figure 2. Institutional Coordination within the Shallot Value Chain

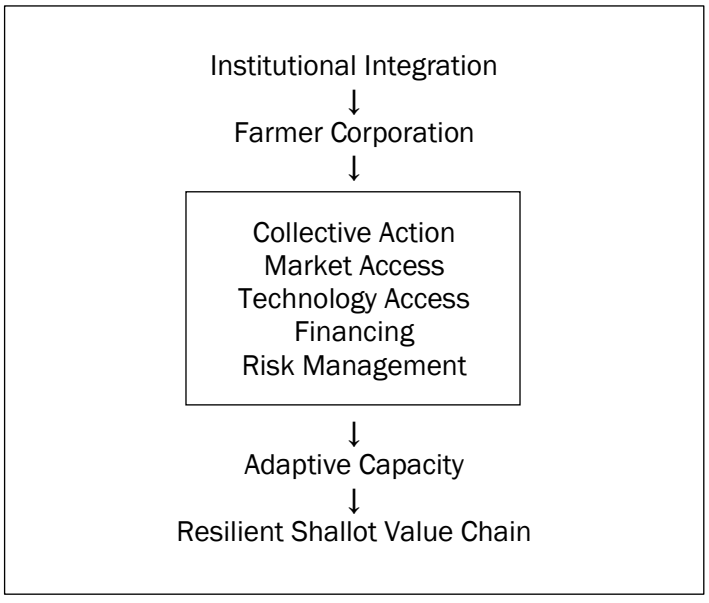
market governance, and institutional support. Therefore, institutional integration is a key requirement for strengthening the adaptive capacity within horticultural value chains.

Farmer Corporations as Institutional Integration Mechanisms

The development of farmer corporations in Majalengka demonstrates an institutional integration approach aimed at strengthening coordination within the shallot value chain (Figure 3). In the Indonesian context, farmer corporations differ from conventional investor-oriented agribusinesses. The farmer corporations in question do not replace existing farmer organizations but rather integrate farmer groups, farmer group associations, cooperatives, and agribusiness services into a coordinated farmer-based governance structure (Jannah et al., 2022).

Operationally, farmer corporations expand the functions of existing farmer organizations by integrating production coordination, financing, input distribution, post-harvest management, and market access into a larger institutional framework. This institutional arrangement enables smallholder farmers to participate collectively in simultaneous value chain activities while maintaining community-based ownership and decision-making processes. A similar institutional integration approach has been linked to closer coordination among production, financing, and marketing functions within smallholder-centered value chains (Widadie et al., 2022).

Figure 3. Farmer Corporations as Mechanisms of Resilience



The results indicate that farmer corporations can strengthen resilience within the shallot value chain through several mechanisms, including collective bargaining, coordinated market access, technological support, financing access, and adaptive responses to climate and market risks. Institutional integration also creates opportunities for stronger partnerships between farmer organizations, government agencies, research institutions, and private sector actors. Such collaboration is essential for increasing technology adoption, strengthening local agribusiness governance, and supporting the long-term sustainability of horticultural systems. Institutional resilience is further strengthened if farmers can collectively coordinate resources, share information, and develop adaptive measures to address environmental and market uncertainties (Folke, 2016; Pani et al., 2022).

Our results suggest that resilience in the shallot value chain is not driven by individual farmer organizations acting independently. Rather, this resilience arises from institutional integration, which enables complementary functions in production, financing, market coordination, innovation support, and risk management. This highlights the importance of farmer corporations as a governance mechanism that connects various stakeholders within coordinated agribusiness systems.

Strategic Priorities for Resilient Shallot Value Chains Development

The strategic assessment highlights that resilient shallot value chains require integrated institutional strategies that combine production support, institutional strengthening, market coordination, and climate adaptation. Although Majalengka benefits from favorable agroecological conditions, institutional support, and expanding market opportunities, farmers continue to face major challenges related to climate variability, unstable prices, pest and disease outbreaks, limited technology adoption, and financing con-

straints. The detailed SWOT results are presented in Appendix E.

Our results indicate that resilient shallot value chains require an integrated institutional strategy that combines production enhancement, institutional strengthening, market coordination, and climate adaptation (Table 3). Strengthening production systems requires land optimization, improved irrigation management, stronger seed systems, and broader access to technological innovations. Productivity gains are often more sustainable when technological advancements are combined with institutional support and management of local resources (Rosenstock et al., 2020; Vishnupriya et al., 2023).

Institutional strengthening is equally important for improving coordination across all agribusiness activities, from upstream to downstream. Farmer cooperatives and corporations can play a strategic role in organizing collective marketing, facilitating access to financing, strengthening farmers' bargaining power, and expanding market networks to achieve this goal. Institutional integration also enables stronger coordination among farmers, government agencies, researchers, and private sector actors to address production and market challenges. Effective value chain governance depends not only on increased production but also on institutional arrangements that facilitate market coordination and collective decision making (Widadie et al., 2022).

Climate adaptation is also a critical strategic priority. Adaptive capacity is increasingly recognized as a vital component of resilient agribusiness systems, particularly in the horticulture sector, which is vulnerable to climate fluctuations (Soesilowati et al., 2026). Increasing climate uncertainty requires adaptive production planning, improved irrigation systems, diversified seed management, and more effective pest and disease management approaches. Community-based institutional coordination can strengthen collective responses to environmental risks and enhance the long-term resilience of horticultural systems (Adegoke et al., 2025).

Table 3. Strategic Priorities for Resilient Shallot Value Chains

Strategic area	Operational focus
Land optimization	Irrigation and cropping management
Institutional strengthening	Cooperative and farmer corporation governance
Technology support	Seed systems and innovation
Climate adaptation	Adaptive farming and risk management
Market integration	Collective marketing and partnerships

Conclusions

This study demonstrates that farmer corporations can serve as an institutional mechanism to strengthen the resilience of the shallot value chain in Indonesia. In the Indonesian context, farmer corporations represent a farmer-based institutional integration model that connects farmer groups, farmer group associations, cooperatives, production coordination, financing, and market governance within a collective agribusiness system, rather than operating as conventional, investor-oriented corporations.

The results indicate that institutional integration strengthens adaptive capacity, enhances collective bargaining power, facilitates market coordination, and supports a more coordinated response to climate and production risks. Therefore, the development of a resilient agribusiness system depends not only on increased production, but also on the capacity of local institutions to collaboratively coordinate upstream and downstream agribusiness activities.

The Majalengka case highlights the importance of institutional governance tailored to local conditions, strengthening farmer-based institutions, and multi-stakeholder collaboration to support sustainable shallot value chains. Policies supporting farmer corporations must focus on institutional capacity, professional management, technological support, access to financing, and long-term coordination among farmers, government agencies, research institutions, and private sector actors.

This study contributes to the broader literature on resilient agribusiness governance by positioning farmer corporations as institutional coordination mechanisms embedded in the local context of smallholder-

based horticultural systems. Our results provide practical and policy insights for other regions seeking to strengthen adaptive and inclusive agribusiness value chains amid economic and environmental uncertainty.

Policy Implications

Our results underscore the importance of institutional governance tailored to local conditions for strengthening resilient horticultural value chains. Policies supporting farmer corporations and related farmer-based institutions should focus on institutional capacity building, professional management, access to financing, technological support, and market integration rather than merely on the formation of organizations. Farmer-led institutional strengthening requires long-term collaboration among local governments, cooperatives, universities, research institutions, and private sector actors. Evidence from smallholder agribusiness systems indicates that institutional strengthening is most effective when governance, financing, technological support, and market coordination are developed simultaneously rather than through separate interventions (Widadie et al., 2022).

In this context, farmer corporations should be understood as institutional coordination mechanisms that strengthen collective agribusiness governance rather than conventional commercial enterprises. The effectiveness of these corporations depends on their ability to integrate local farmer organizations, support collective action, and coordinate value chain activities in the face of economic and environmental uncertainty.

The Majalengka case demonstrates that the development of resilient shallot value chains is closely linked to institutional integration, collaborative governance, and adaptive capacity at the local level. Strengthening these institutional arrangements can support a more inclusive, adaptive, and sustainable horticultural system in Indonesia and other regions facing similar agribusiness challenges.

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Appendix A. Farmers' Perceptions of Shallot Value Chains and the Performance of Farmers' Organizations

Farmers' perception level refers to their comprehension and interpretation of each attribute in the set of questions about shallot value chains and farmer organizations, which is then scored as a subjective view of each attribute. Farmer perceptions were assessed using a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Perception scores were divided into three categories of perception level intervals according to the formula by Marcelina et al. (2018):

$$Class\ Interval = \frac{Highest\ Value - Lowest\ Value}{(t2 - t1) Number of\ Class\ Intervals}$$

The perceptual level had the following class interval values: high = 3.68–5.00, medium = 2.34–3.67, and low = 1.00–2.33.

Appendix B. SWOT Analysis

A SWOT analysis was used to create a plan for developing shallots value chains based on farmer corporations in Majalengka. The analysis procedures were performed in accordance with LAN (2008) as follows:

1. Identify the internal and external elements influencing the shallot value chain in Majalengka farmer corporations, including strengths (S), weaknes (W), opportunities (O), and threats (T).
2. Identify three priority internal elements in S and W and three priority external factors in O and T.
3. The urgency value (UV) is determined to determine the factor weights (FW) for internal and external factors. The UV value was calculated by comparing the importance of one element to that of others in the group of internal and external factors. The UV value ranges from 1–5, with a higher value indicating that the relevance between one component and the other is extremely high. The FW value is derived by dividing the sum of each factor's UV by the total value of the internal and external factor groups and then multiplying by 100.
4. The key success factors (KSF) were determined by evaluating the interrelationship between internal and external factors based on their support value (SV), and calculating the support weight value (SWV), average linkage value (ALV), linkage weight value (LWV), and total weight value (TWV). The SV value ranges from 1–5, indicating that the higher the SV value, the more support a factor receives. The relatedness value (RV) is scored on a scale of 1–5, the greater the RV value, the more related the factor. KSF was chosen based on the highest TWV of each factor, S, W, O, and T. The specific calculations for each factor analysis were as follows:

   SWV = FW x SV
   ALV = Total VR/n-1
   LWV = ALV x FW
   TWV = LWV + SWV

5. Create a strength map based on the findings of the internal-external factor relationship assessment. The strength map was generated by comparing the TWV of all S values to all W values and the TWV of all O values to all T values.
6. Create a development strategy utilizing SWOT strategy formulation. The four SWOT quadrants listed in Table 1 can be used to generate four major strategies.
7. Create policy recommendations for important programs and activities using data from observations, in-depth interviews, and direct conversations with respondents.

Table B1. The SWOT Strategy Formulation

Quadrant	Strategy	Description
1	Expansion (S–O)	Utilize S to accomplish O
2	Diversification (S–T)	Use S to decrease T
3	Stability or rationalization (W–O)	Overcoming W by using O
4	Defensive or survival (W–T)	Improve W by decreasing T

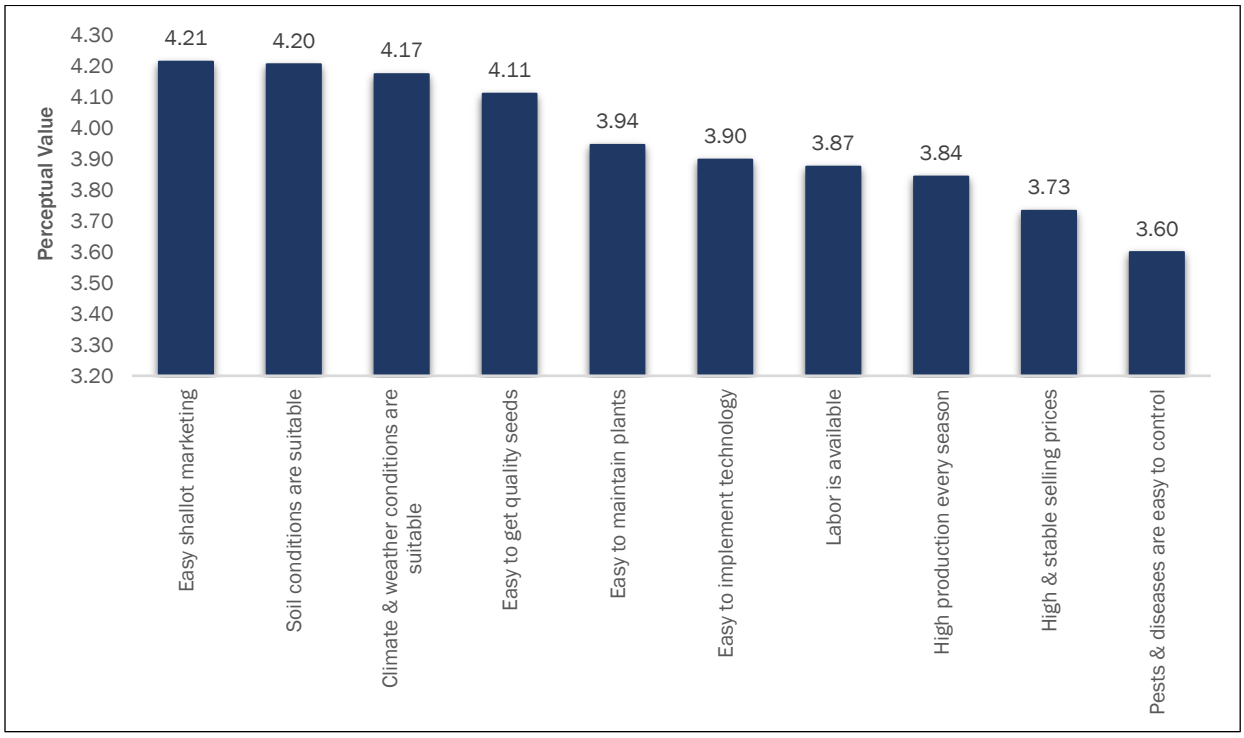
Appendix C. Characteristics of Farmers and their Perceptions of Shallot Value Chains

Table C1. Farmers' Characteristics

Description	Criteria	Amount (%)	Mean	Std.
Age (Years)	≤30	22 (15.75)	43.28	12.05
	31–40	31 (22.05)		
	41–50	43 (30.71)		
	51–60	33 (23.62)		
	≥61	11 (7.87)		
Education (Years)	≤6	52 (37.01)	9.30	3.34
	7-9	37 (26.77)		
	10–12	40 (28.35)		
	≥13	11 (7.87)		
Farming Experience (Years)	≤10	67 (48.03)	14.55	9.92
	11–20	41 (29.13)		
	21–30	25 (18.11)		
	≥31	7 (4.72)		
Number of Family Dependents (People)	≤2	38 (29.920	3.03	1.23
	3–5	86 (67.71)		
	≥6	3 (2.36)		
Cultivated Area (ha)	≤0.25	53 (37.80)	0.55	0.54
	0.26–0.50	40 (28.35)		
	0.51–0.75	11 (7.87)		
	0.76–1.00	20 (14.17)		
	≥1.00	16 (11.81)		
Household Income (USD)	≤ 122.14	34 (24.29)		
	128.24–213.74	53 (37.86)		
	219.85–305.34	28 (20.00)		
	≥ 311.45	25 (17.86)		
Household Expenditure (USD)	≤ 122.14	43 (30.71)		
	128.24–213.74	67 (47.86)		
	219.85–305.34	25 (17.86)		
	≥ 311.45	(3.57)		

Note: 1 USD = IDR 16,375 (Bank Indonesia, 2024)

Figure C1. Farmers' Perceptions of Shallot Value Chains



Appendix D. Farmers' Perceptions of Farmer Organization Performance and their Preferences Regarding Institutions in Corporate-Based Shallot Value Chains

Figure D1. Farmers' Perceptions of Farmer Organizations in Shallot Value Chains

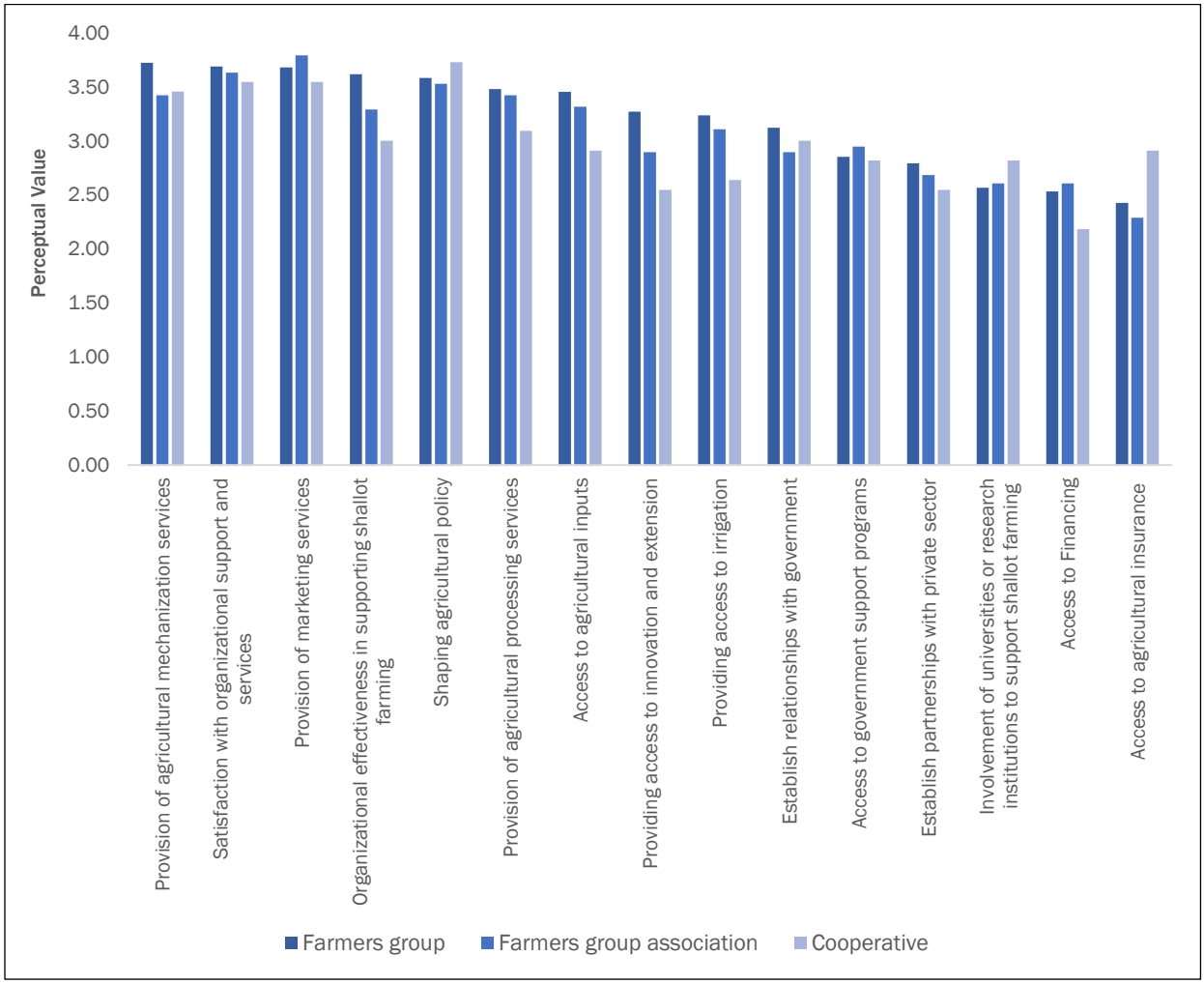
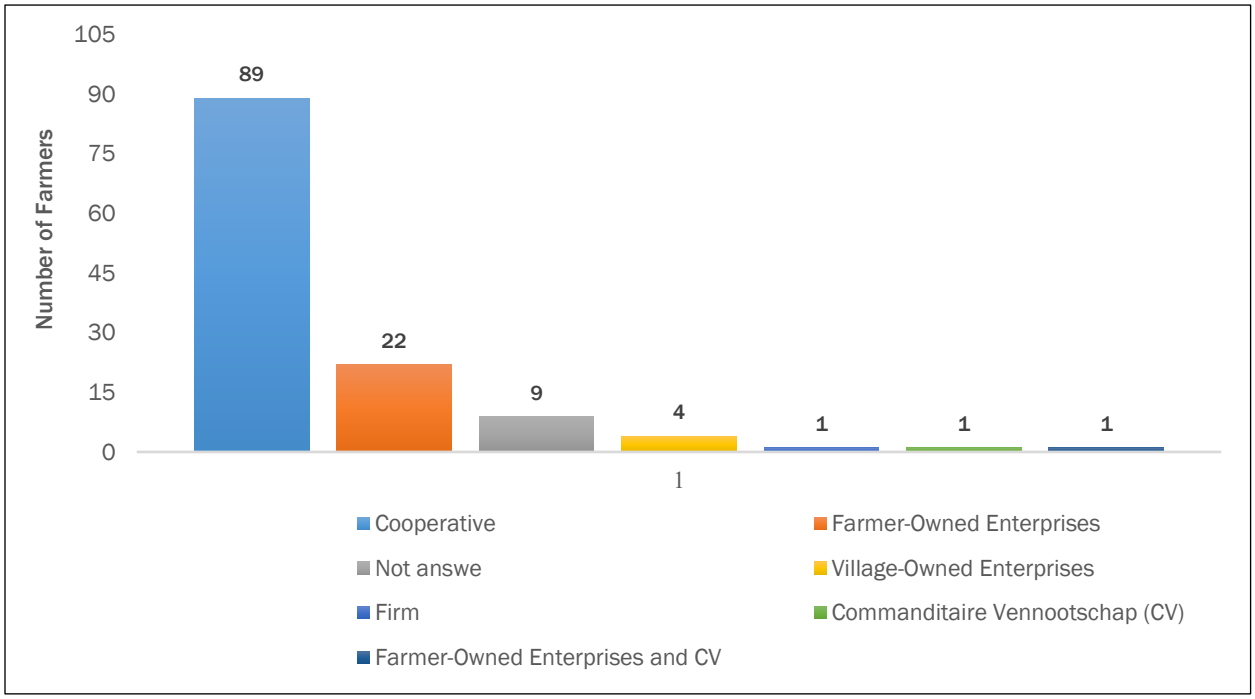


Figure D2. Farmers' Preferences Regarding Institutions Involved in the Development of Farmer Corporation-Based Shallot Value Chains



Appendix E. Results of the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Table E1. Prioritized Internal and External Factors Based on the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Priority	S	W	O	T
1	Land for shallot development (50.00%)	Technology was not deployed, and most farmers did not employ certified seeds (53.33%)	The market remained open (60.00%)	Extreme weather and natural disasters (63.33%)
2	Number of shallot farmers (30.00%)	Infrastructure (cold storage, shortage of seed producers in developing areas, etc.) remained limited (26.67%)	Production can co-fluctuate (30.00%)	Shallot prices often fluctuate (26.67%)
3	Government policy support (20.00%)	Limited capital (20.00%)	Development of independent farmer groups (local champions) as seed breeders (10.00%)	High pests and diseases (10.00%)

Notes: Primary data from 2024. The figures in parentheses show the percentage of participants.

Table E2. Evaluation of Internal and External Factors Based on the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Internal and external factors	FW (%)	SV	SWV	ALV	LWV	TWV	KSF
S						1.39	
Land for shallot production	26.67	5	1.33	2.91	0.78	1.03	1
Number of shallot farmers	20.00	4	0.80	1.91	0.38	0.31	2
Government policy support	6.67	4	0.27	2.64	0.18	0.05	3
W						0.85	
Technology is not used and most farmers do not use certified seeds	20.00	4	0.80	3.18	0.64	0.51	1
Infrastructure (cold storage and scarcity of seed providers in developing areas) remains restricted	20.00	3	0.60	2.64	0.53	0.32	2
Limited capital is available	6.67	3	0.20	2.18	0.15	0.03	3
O						1.08	
The market remains open	26.67	4	1.05	3.09	0.81	0.85	1
Production levels can still be increased	13.33	3	0.40	2.55	0.34	0.14	2
Establishment of independent farmer groups (local champions) as seed breeders	13.33	2	0.27	2.45	0.33	0.09	3
T						0.73	
Extreme weather or natural disasters	26.67	4	1.07	2.09	0.56	0.59	1
Shallot prices fluctuate frequently	13.33	3	0.40	2.36	0.32	0.13	2
Pests with high illness levels	6.67	2	0.13	1.45	0.10	0.02	3

Figure E1. Strength Map of Shallot Value Chains Based on Farmer Corporations

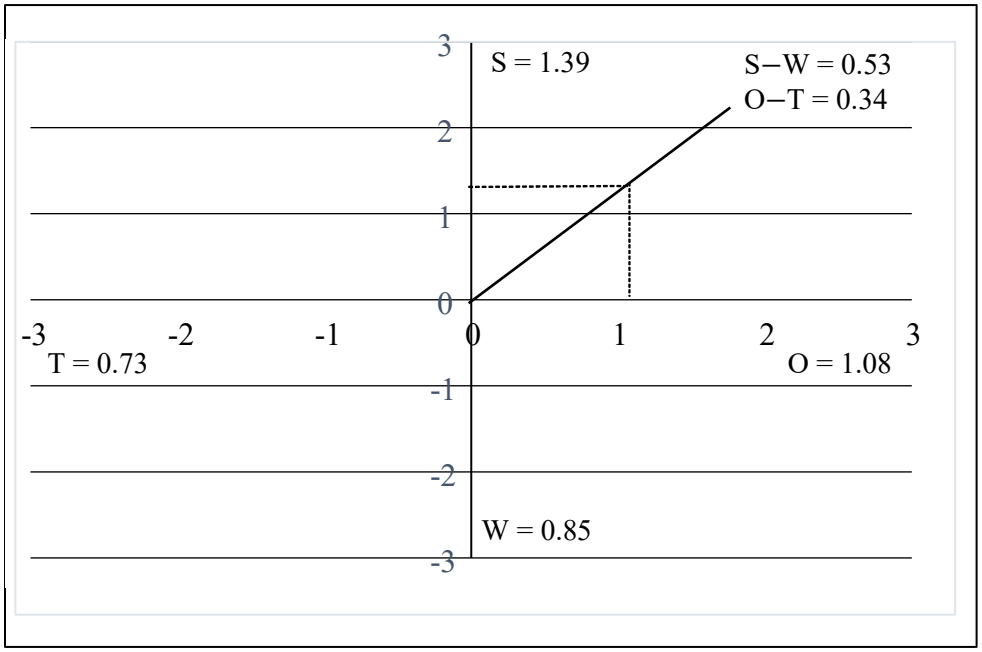


Table E3. SWOT Strategy Formulation for Farmer Corporation-Based Shallot Value Chains

Internal Factors / External Factors	**Strength (S)** Land for shallot development	**Weakness (W)** Inadequate utilization of technology and certified seeds by farmers
Opportunities (O) The marketplace is still open	**S–O** Optimizing land to fulfill open market demand	**W–O** Increased productivity by market-oriented production practices for market expansion
Threats (T) Extreme weather and natural disasters	**S–T** Optimizing land management to improve resilience against climate and environmental risks	**W–T** Improved farming techniques using climate-adaptive technology

Table E4. Operational Recommendations for Programs and Actions on Corporate-Based Shallot Value Chains in Majalengka

No.	Program	Activity
1	Land optimization uses location-specific production enhancement technology to suit the market demand that is still available both nationally and for export.	a. Creating location-specific SOPs for high-production shallot value chains. b. Mapping land availability based on planting time, input readiness and affordability, and output potential per unit area and time. c. Improving land productivity by boosting the cropping index and promoting land improvement and conservation. d. Establishing institutions for producing and marketing shallots. e. Expanding marketing networks nationally and internationally.
2	Increased farmer capacity and competence for increased shallot production.	a. Identifying existing and new technologies as the basis for closing a production increase gap. b. Strengthening research institutions, universities in the region, and government agencies in technology dissemination, as well as assistance and supervision of technology application. c. Accelerating access to technological innovation through various conventional and digital media. d. Building institutions to increase farmers' capacity and competence.
3	Government policy to build shallot upstream-downstream value chain institutions based on the potential resources of the region	a. Strengthening public trust in farmer corporation-based shallot value chain development. b. Strengthening the roles of both formal and informal institutions related to the upstream-downstream value chain of shallots, especially for seed producers and water management. c. Strengthening existing institutions as local champions toward broader institutions, both in terms of business fields and stakeholders involved. d. Developing inclusive upstream-downstream shallot agribusiness institutions involving farmers, government agencies, and private-sector actors.

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Why do producers decide not to join agricultural associations? The case of the Ataulfo mango in southern Mexico

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Abstract

The Ataulfo is an economically valuable mango variety originating in the Soconusco region of Chiapas, Mexico. Some, but not all, producers are members of marketing organizations. This study sought to evaluate how membership in a marketing organization impacts the livelihood viability of producers in the Soconusco and Istmo-Costa regions. From January 2020 to December 2021, we surveyed 126 producers (34 association members and 92 nonmembers), representing 3% of all Ataulfo producers in the study area. Using cluster analysis, we identified five unique groups of producers: Group 1 (G1), Packing-linked producers (2 producers, 1.6%); Group 2 (G2), Resource-limited producers (48 producers, 38.1%); Group 3 (G3),

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Intermediate commercial producers (55 producers, 43.7%); Group 4 (G4), Multimarket producers (12 producers, 9.5%); and Group 5 (G5), Export-specialized producers (9 producers, 7.1%). We found that social capital, as represented by association membership, appears to influence the viability of mango growers in diverse and international markets. However, among nonmember producers, those in G3 obtained high profits despite not being organized. While association membership enhances the profitability of G4 and G5, it did not limit the reserves of financial capital in G3. Contrary to the literature suggesting that lack of organization undermines viability, our findings indicate that some nonmember producers achieved high profitability. This result suggests that Ataulfo growers can be successful without belonging to a producer organization. However, socio-environmental threats, such as the advanced age of producers, lack of generational succession, low income, and varying levels of insurance among nonmember groups, pose risks to their long-term viability.

Keywords
producer organizations, producer types, system diagnosis, mango orchards, economic evaluation, market diversity, Ataulfo mango

Introduction

Fruit production, particularly mango, is an important sector of the Mexican export economy. In 2022, Mexico produced 2.17 million tons of mango, with its principal export destinations being the U.S., Canada, and Japan (Sistema de Información Agroalimentaria y Pesquera [SIAP], 2024). Ataulfo mango originated from the Soconusco and Istmo-Costa regions (De la Torre González, 2013), which extend along the Pacific Coast of Chiapas, Mexico. This variety received a denomination of origin granted by the Mexican Institute of Industrial Property and published in the Official Gazette of the Federation (Diario Oficial de la Federación [DOF], 2003). The fruit is prized for its high quality and notable health benefits (Vélez-de la Rocha et al., 2024). In 2024, 31,116 hectares of Ataulfo mango were harvested in these regions, yielding on average 7.79 tons per hectare per year with an average price of approximately US$299.90 per ton. Among mangoes, the Ataulfo ranked first nationally in production (242,419 t) and production value (US$72 million) (SIAP, 2024).

Research shows that mango farmers can derive many benefits from forming an association. Organized producers can benefit from competitive advantages in the production and marketing of fruit, which can contribute to improved living standards (Czapiewska, 2021; García, 2000; Rodríguez-Herrera, 2020; Rondot & Collion, 2001). Studies from Ethiopia show that mango producers in associations are 56% more likely to sell more (Hagos et al., 2020). Similarly, Musyoka et al. (2020) reported that group membership increases the probability of engagement in mango value-addition activities by 1.93 percentage points in Kenya.

On the other hand, the literature suggests mango producers who are not members of an association are at a disadvantage compared to member producers. Muthini et al. (2017) and Rasmikayati et al. (2020) independently showed that nonmember mango producers experience reduced power to negotiate sale prices, lack market information, suffer excessive costs for transportation and logistics, and lack access to markets.

The situation in Mexico is similar to that in other countries. Studies by government agencies and producer associations indicate inadequate organization among producers. According to the National Master Plan for the Mango Product System (Comité Nacional Sistema Producto Mango [CONASPROMANGO], 2012; Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación [SAGARPA], 2004), lack of organizational structures results in poor coordination along the value chain; dependence on intermediar-

Author Note
Sumuano-Barragán's graduate thesis is the basis for this article (Sumuano-Barragán, 2025).

Conflicts of Interest
The authors declare no conflicts of interest.

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ies for commercialization; limited adoption of post-harvest quality standards; and insufficient infrastructure for storage, packing, and processing. These deficiencies reduce producers' bargaining power, restrict access to credit and government programs and hinder competitiveness in both national and export markets.

Moreover, a report by the Mexican federal government concerning the production of Ataulfo mango in Chiapas recommended improving producer organization to consolidate the market, that is, improving coordination among growers so that they can pool harvests, ensure consistent quality, and negotiate better prices. Such collective action reduces fragmentation in the value chain and allows producers to compete more effectively in national and export markets (SAGARPA, 2017).

Although becoming a member of an agricultural association can provide several advantages, studies suggest many producers are reluctant to join. In Venezuela, for example, only 15% of 95 smallholder farmers of different types of crops were members of a producer association (Rincón et al., 2004). In Nigeria, Mbah (2018) found that most of the smallholder poultry farmers he interviewed were not integrated into a producer association (93.8% of 80 interviewees). In Slovakia, Michalek et al. (2018) found that 54% of 939 agricultural producers did not belong to any organization. In Mexico, 77% of the interviewed amaranth (*Amaranthus* spp.) producers were not members of an organization (Ayala-Garay et al., 2016). Also in Mexico, Coutiño et al. (2017) reported that 32.3% of the coffee producers (62 interviewees) were not integrated into an organization and that they suffered significant competitive disadvantages compared to member producers. Similar situations have been reported for mango production. For example, in Kenya (Muthini et al., 2017), Indonesia (Rasmikayati et al., 2020), and Bangladesh (Kok et al. 2021), 54.2, 55.0% and 63.3% of the producers, respectively, were not members of a mango producer organization.

If membership in a producer association appears to provide many benefits to its members, then why do producers decide not to join? To answer this question, we investigated the socio-environmental system of the Soconusco and Istmo-Costa regions with the following objectives: (1) to categorize Ataulfo mango producers of the Soconusco and Istmo-Costa regions, and (2) to compare the competitive advantages of member producers to those of nonmember producers. Accordingly, we analyzed the differences between producer groups through the concept of capital reserves and propose strategies to improve organization among producers in the region.

We employed the capitals framework of the Wageningen Center for Development Innovation (WCDI) (2020) for use in an agricultural context. Accordingly, capital reserves can be classified into human capital, which refers to the skills, knowledge, and health of the producers; social capital, which encompasses relationships, networks, and social norms; and financial capital, which refers to monetary resources, including income, savings, and access to credit. WCDI extends the capitals frameworks to organizational decision-making. When farmers join an association, they invest part of their financial and social capital, and the organization manages this contribution and decides whether to reinvest profits into infrastructure and services or to distribute them among members. In both cases, the outcome can increase the value of membership and broaden livelihood opportunities. These approaches underscore the relevance of financial and social capitals in the organizational dynamics of agricultural associations, as well as the relationship between the investment of capital and the welfare of the organization's members.

Methods

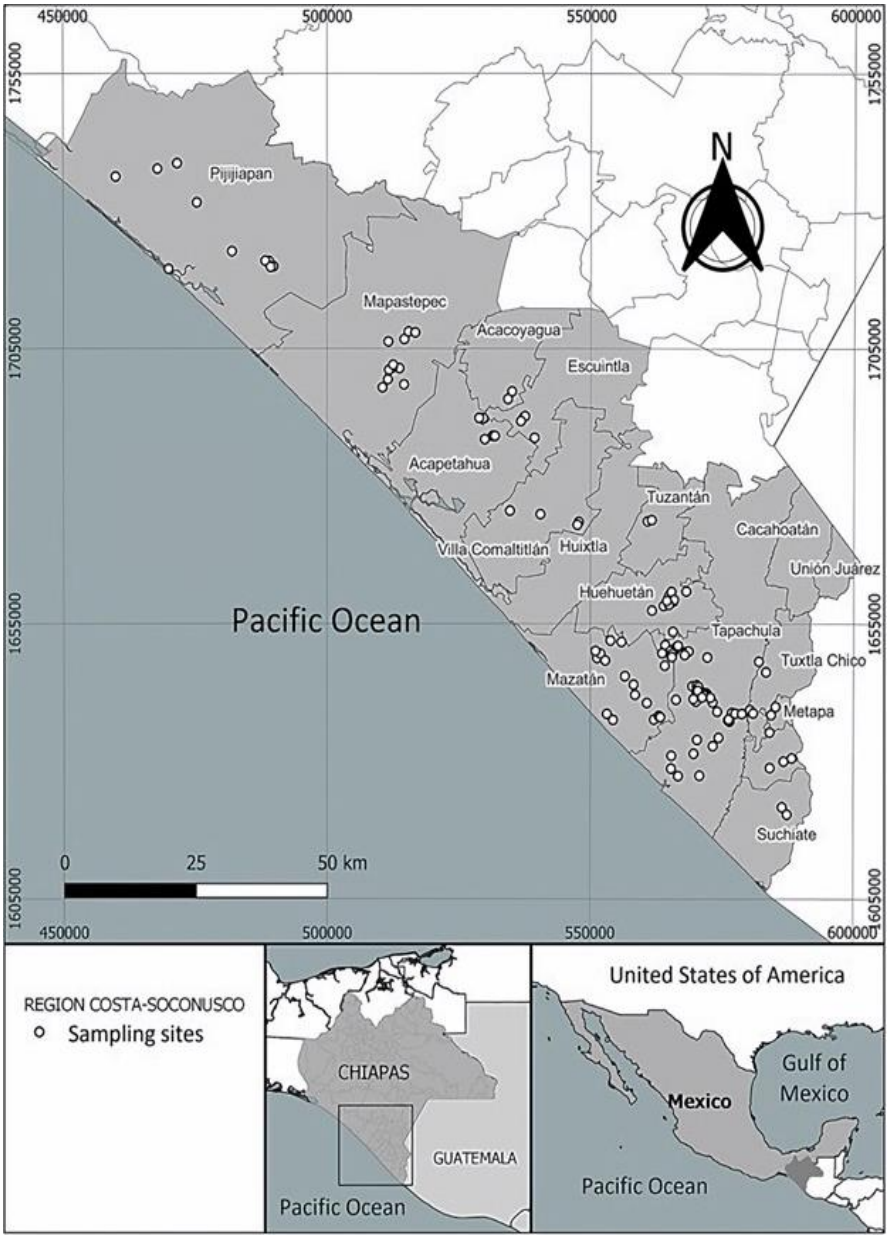
This section describes the geographic setting of the study, the interview and sampling procedures, and the analytical framework used to classify Ataulfo mango producers according to their human, social, and financial capital reserves, as well as the statistical approach used to compare producer groups and evaluate their economic performance.

Study Area

The study was conducted from January 2020 to December 2021 in Ataulfo mango orchards in the Soconusco and Istmo-Costa regions, which are located in the south of the State of Chiapas, Mexico and extend along the Pacific Coast. Our

study included 103 orchards in municipalities in the Soconusco region: Acacoyagua (2 orchards), Acapetahua (4), Escuintla (5), Frontera Hidalgo (5), Huehuetán (11), Mazatán (15), Suchiate (2), Tapachula (52), Tuxtla Chico (1), Tuzantán (2), and Villa Comaltitlán (4); and 23 orchards in municipalities in the Istmo-Costa region: Mapastepec (12) and Pijijiapan (11) (Figure 1). These regions are characterized by tropical and subtropical climates. The predominant climate type is warm and subhumid with abundant summer rains. The average annual temperature ranges from 22.5 to 28.5ºC (72.5º to 83.3º F). Rainfall ranges from 1200 (47.2 in) to more than 3000 mm (118.1 in) (Comité Estatal de Información Estadística y Geográfica de Chiapas [CEIEG], 2011; Escalante-Sandoval & Amores-Rovelo, 2014).

Figure 1. The Distribution of Sampled Mango Orchards in the Soconusco and Istmo-Costa Regions, Chiapas, Mexico



The surveyed orchards ranged from 6 to 183 meters (19.7 to 600.4 feet) above sea level (m.a.s.l.), with an average altitude of 46.12 m (±4.36 m standard error), mostly located in lowland areas below 60 m. According to the Ataulfo mango denomination of origin, the predominant soils are chromic luvisols and eutric fluvisols, which are fertile and well-drained (DOF, 2003).

Qualitative Interviews

In total, 126 producer interviews were conducted, representing approximately 3% of the existing Ataulfo mango producers of the study area (P. Leal, personal communication, February 12, 2022). Of the interviewees, 34 reported being members of a local producer association and 92 reported being nonmembers. These 34 members were distributed across six producer associations. These organizations were legally diverse: one was a civil association, four were rural production societies, and one was union of *ejidos*, an organization that brings together several communities of communal landowners. The survey was

based on a 68-question questionnaire that addressed socioeconomic, financial, and organizational aspects ordered by type of capital reserve. Each interview lasted between one and two hours.

Because data collection took place during the COVID-19 pandemic, interviews were conducted outdoors, in the orchards, following the health measures recommended by health authorities (use of masks, physical distancing, and small group sizes) to prevent contagion. During the interviews, no behavioral changes associated with COVID-19 were observed among producers that could affect data collection or the research results.

Data Analysis

This section describes the statistical procedures used to identify producer groups, classify their characteristics by type of capital, compare variables across groups, and evaluate the economic performance of each group.

Identification of Producer Groups

Data from the 126 producers was compiled in Microsoft Excel and analyzed using the software package R (R Core Team, 2021). Cluster analysis was used to determine producer groups. This method was selected because it is an exploratory, data-driven technique that identifies producer groups based on multivariate similarity without requiring the number or composition of groups to be specified in advance (Everitt et al., 2011). Per the approach recommended by Zar (2010), the number of groups was defined based on the first major jump in the dendrogram. This approach is well suited to livelihood-capital studies where the structure of heterogeneous producer populations is not known a priori; it has been applied in comparable typology studies of smallholder agricultural systems and in broader farming systems research (Alvarez et al., 2018).

Classification of Variables by Type of Capital

Variables related to producers and their orchards were classified by type of capital (human, social, and financial) within each of the identified producer groups.

The variables included in each capital domain were selected based on two criteria: (1) their conceptual alignment with the Sustainable Livelihoods Framework (SLF) (Department for International Development [DFID], 1999; Serrat, 2017), and (2) their documented relevance to mango producer characterization in the empirical literature (Kok et al., 2021; Muthini et al., 2017; Rondot & Collion, 2001). Human capital variables reflect productive capacity and skills at the individual and household level, as defined by the SLF; social capital variables capture the relational and institutional dimensions that mediate market access and collective action; and financial capital variables characterize monetary resources and financial management capacity, which are primary determinants of viability in smallholder systems (DFID, 1999; Serrat, 2017).

The variables of human capital include gender, age, level of schooling, number of children who help their parents in the orchard, number of people living at home, health status, and knowledge and implementation of agroecological strategies.

The social capital variables in the study include the importance of mango in the household economy, homeownership, membership in an organization, and technical assistance.

Financial capital includes tracking production costs, saving or investing, percentage of savings, sources of financing, insurance, sources of income, methods of selling the harvest, sales market, buyers, income from mango harvest per hectare, cost of production per hectare, and daily income.

Comparison of Variables Between Producer Groups

Chi-square contingency tables (χ^2) were generated in the software package R to determine differences between producer groups based on variables related to producers and their orchards. The degrees of freedom were calculated using the formula $(r - 1)(c - 1)$, where r and c represent the number of rows and columns, respectively. To compare producer groups, contingency tables were subjected to correspondence analysis for $c \geq 3$ (Mardia et al., 1979) and examined with standardized residuals for $c = 2$ (Agresti, 2012). Groups with five or fewer producers were excluded from the analyses.

Economic Analysis

The value of production and profit per ha and per

orchard are based on information obtained from 52 interviewed producers (41.3% of the total number of producers) who knew their cost of production and yield of mangos. Calculations started from a regional average selling price of MX$7000 (US$348.78) per ton of Ataulfo mango in 2021–2022 (P. Leal, personal communication, February 2022). Mexican pesos (MX$) were converted to U.S. dollars (US$) using an exchange rate of MX$20.07 per U.S. dollar (Statista, 2024). Chi-square contingency tables (Pearson's χ^2, $P \leq 0.05$) were used to compare economic variables (production costs, production value, and profit) between producer groups.

It should be noted that the 52 producers included in the economic analysis do not constitute a random subsample of the 126 interviewed, because the producers with knowledge of their production costs were disproportionately concentrated in G4 (multimarket producers) and G5 (export-specialized producers), whereas the vast majority of G2 (resource-limited producers) and G3 (intermediate commercial producers) did not record this information (Table 1).

Results

The following sections present the classification of producer groups, their characteristics according to type of capital, and the economic analysis of mango production across groups.

Classification of Producer Groups

Cluster analysis yielded five distinct producer groups (Figure 2; Appendix Table A1).

G1 (**Packing-linked producers**), although small in number, are characterized by direct integration with packing facilities (100%), enabling participation in national (50.0%) and international (50.0%) markets. Their commercial integration illustrates one pathway of market access that does not necessarily depend on having large scale but instead on strategic positioning within commercialization channels.

G2 (**Resource-limited producers**) are characterized by small-scale orchards (87.5% ≤10 ha), lower schooling levels, minimal technical assistance (2.1%), limited organizational participation (18.7%), and strong orientation toward local markets (77.1%). This configuration results in the lowest profits per hectare and per orchard, reflecting structural constraints in capital accumulation.

G3 (**Intermediate commercial producers**) occupy an intermediate structural position. Despite limited organizational membership (16.4%), they achieve the highest profitability per hectare and strong participation in national markets (87.3%),

Table 1. Statistical Comparison of Groups of Ataulfo Mango Producers with Respect to Variables Related to Financial Capital in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

	Chi-square test [a]		
Variable	χ^2	df	*P*
Tracking production costs	53.81	3	<0.001
Saving or investing	22.60	3	<0.001
Percentage of savings	6.27	6	0.393
Sources of financing	41.96	15	<0.001
Insurance	54.48	12	<0.001
Sources of income	16.44	9	0.058
Ways of selling the harvest	40.21	3	<0.001
Sales market	73.73	18	<0.001
Buyers	78.03	15	<0.001
Income from mango harvest per ha	25.00	9	<0.002
Cost of production per ha	35.07	9	<0.001
Daily income	69.67	15	<0.001

[a] Chi-square contingency tables (χ2) were generated to determine differences between producer groups. G1 was excluded from the analysis due to its small size (n = 2) of producers.

with partial participation in international markets (41.8%) through indirect commercialization channels.

G4 (**Multimarket producers**) are characterized by higher organizational integration (75.0%), diversified market participation (66.7% national and 66.7% international), and regular access to technical assistance (41.7%). Their larger orchard sizes and diversified commercialization strategies reflect a combination of productive and organizational capital.

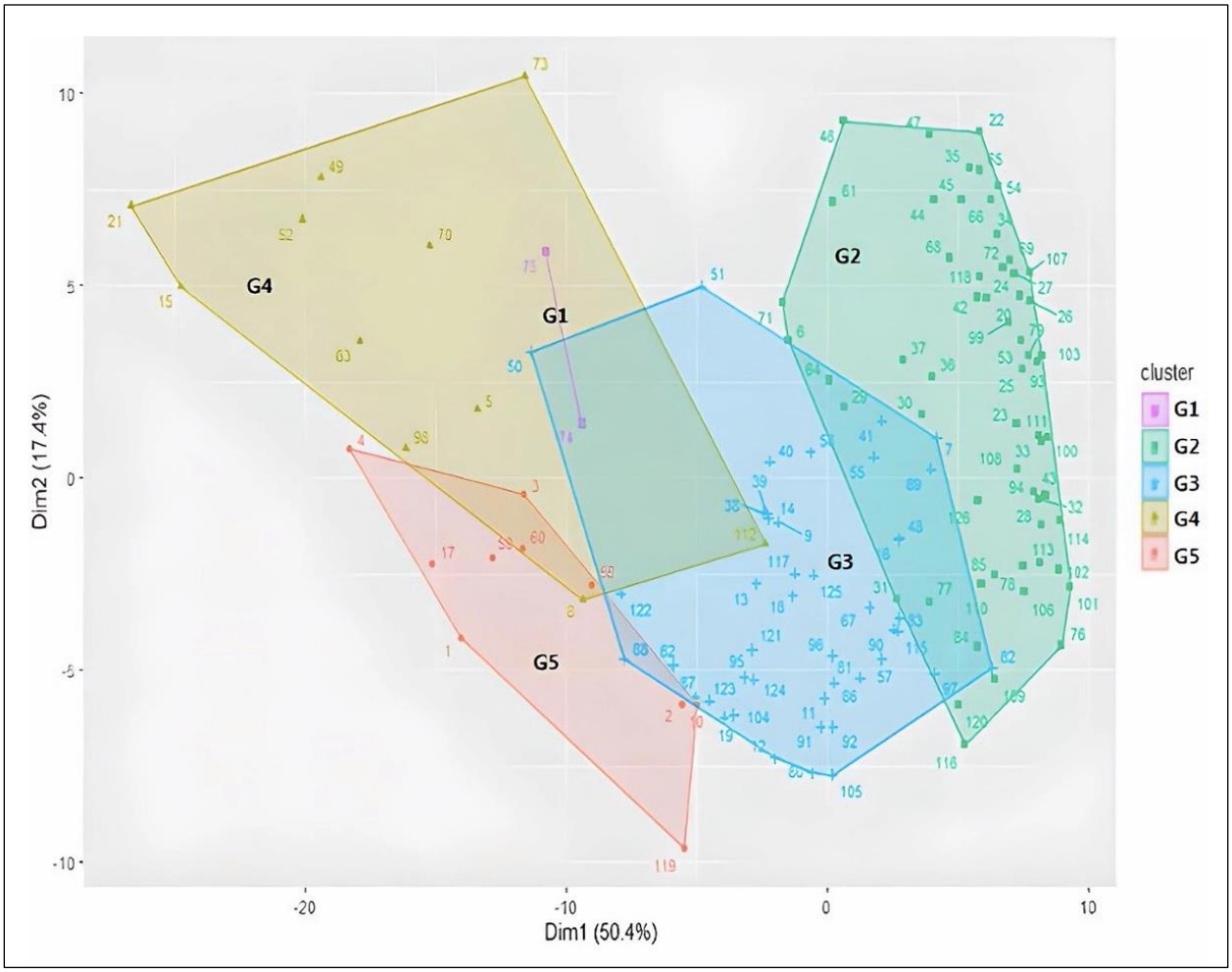
Finally, **G5** (**Export-specialized producers**) represent the highest level of commercial specialization, with large orchards (55.6% ≥ 31 ha), strong technical support (100%), organizational membership (66.7%), and full participation in international markets (100%). This group achieves the highest total profits per orchard, reflecting advanced integration into export-oriented value chains.

The number of producers per group was as follows: G1: 2 producers (1.6%); G2: 48 producers (38.1%); G3: 55 producers (43.7%); G4: 12 producers (9.5%); and G5: 9 producers (7.1%).

For the cluster analysis, orchard sizes were as follows: smallest orchards were found in G2 (resource-limited producers) with 2.86 ± 0.34 ha, followed by G3 (intermediate commercial producers) with 8.89 ± 1.46 ha. G1 (packing-linked pro-

Figure 2. Cluster Analysis of 126 Ataulfo Mango Producers in the Soconusco and Istmo-Costa Regions, Chiapas, Mexico

G1, packing-linked producers (2 producers, 1.6%); G2, resource-limited producers (48 producers, 38.1%); G3, intermediate commercial producers (55 producers, 43.7%); G4, multi-market producers (12 producers, 9.5%); and G5, export-specialized producers (9 producers, 7.1%).



ducers) averaged 16.75 ± 3.42 ha, while G4 (multi-market producers) averaged 20.6 ± 8.02 ha. The largest orchards were observed in G5 (export-specialized producers), with 43.44 ± 12.70 ha.

Characteristics of Producer Groups by Type of Capital

This section describes the characteristics of each producer group with respect to human, social, and financial capital.

Human Capital

Although mango producers across the region shared similar demographic characteristics—such as gender distribution, age, family size, and health status—they differed notably in educational attainment and knowledge of agroecological practices (see Table 2; Appendix Table A2). G2 and G3 had the lowest education levels (high school or less), while G5 included university-educated producers, and G4 had members with postgraduate degrees. Similarly, producers in G5 showed higher awareness and implementation of agroecological strategies, distinguishing them from the other groups that had lower engagement with sustainable practices.

Social Capital

Although the importance of mango in household economies and homeownership rates was similar across all five producer groups, notable differences were observed in dimensions of social capital (Table 3; Appendix Table A3). Producers in G4 and G5 had significantly higher organizational participation, with 75% and 67%, respectively, belonging to mango production and marketing associations, in contrast to the lower and statistically similar membership rates in G2 and G3. The

Table 2. Statistical Comparison of Groups of Ataulfo Mango Producers with Respect to Variables Related to Human Capital in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

	Chi-square test [a]		
Variable	χ^2	df	*P*
Gender	1.66	3	0.653
Age	3.19	3	0.362
Level of schooling	44.44	18	<0.001
Number of children who help their parents in the orchard	4.63	6	0.590
Number of people living at home	4.01	9	0.910
Health status	6.43	6	0.376
Knowledge and implementation of agroecological strategies	14.42	3	<0.002

[a] Chi-square contingency tables (χ2) were generated to determine differences between producer groups. G1 was excluded from the analysis due to its small size (*n* = 2) of producers.

Table 3. Statistical Comparison of Groups of Ataulfo Mango Producers with Respect to Variables Related to Social Capital in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

	Chi-square test [a]		
Variable	χ^2	df	*P*
Importance of mango in the household economy	15.33	9	0.082
Homeownership	6.77	3	0.790
Membership of an organization	26.25	3	<0.001
Technical assistance	43.27	3	<0.001
Had received technical assistance	43.70	3	<0.001

[a] Chi-square contingency tables (χ2) were generated to determine differences between producer groups. G1 was excluded from the analysis due to its small size (*n* = 2) of producers.

most common reason for nonmembership was a personal preference not to join (n = 34; 37%; Figure 3). Access to technical assistance also varied among groups. Nearly all producers in G5 reported receiving current or past technical support, whereas only a small proportion of G2 receive (2.1%) or received (4.2%) technical assistance. G3 and G4reported intermediate and similar levels of assistance. These patterns indicate that organizational affiliation is closely linked to improved access to technical knowledge and institutional support, which can enhance productivity and integration into formal markets.

Financial Capital

Significant differences in financial capital were observed among the five producer groups, despite similar savings percentages and sources of income (see Table 1; Appendix Table A4). Only 19.8% of producers tracked production costs, with G4showing the highest awareness and G2 the lowest. Most producers (76.2%) reported neither saving nor investing income, except in G4, where this was more common. Nearly half (43.1%) lacked access to financing, and among those who had access, family support was predominant, especially in G2, G3, and G4. G5 producers stood out by using formal credit (bank and/ or government loans) and mixed financing schemes. Insurance coverage was very low: no producer held agricultural insurance, and only a few (7.9%) had health, life, or social security coverage (Mexican Social Security Institute, Institute for Social Security and Services for State Workers, or Popular Health Insurance), mostly outside G2 and G3 producers. Most producers (65.9%) relied on mango sales plus one additional income source, though G4 and G5 producers had more diversified incomes. Sales practices varied: Overall, 63.5% sold unharvested fruit to intermediaries ("coyotes"), especially in G2. In contrast, G5 harvested and sold mangoes themselves, selling internationally. Most producers sold to orchard-renters (buyers who lease orchards from producers to harvest and sell the fruit themselves) in G2, but G3, G4, and G5 had more direct or formalized sales to packhouses or national and/or regional markets.

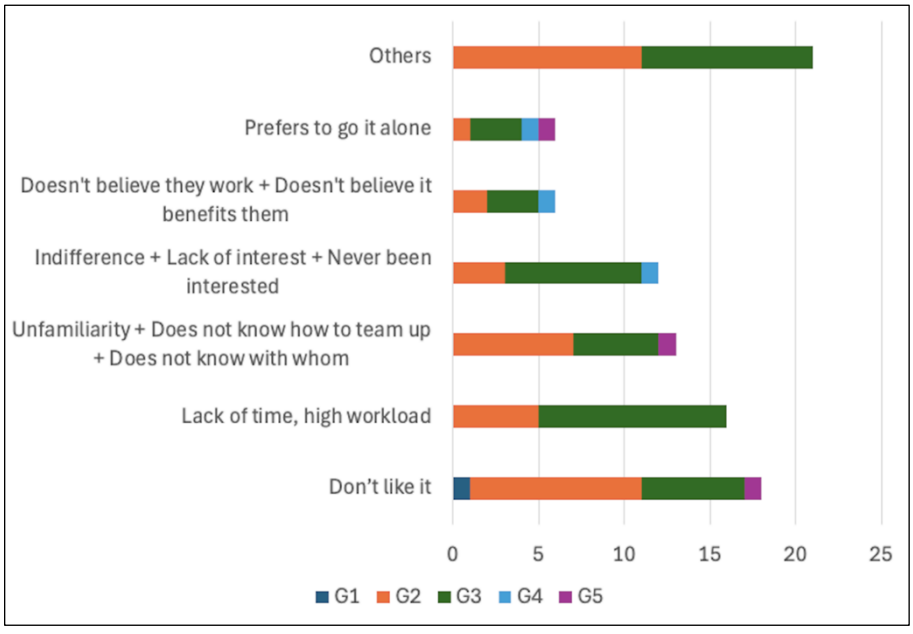
Economic Analysis of Mango Production

Analysis of the economic variables of the producer groups showed that export-oriented and organized members generally achieved higher profitability (see Table 4; Table A5).

Production Costs per Hectare per Year (US$)

Mean production costs (± standard error) of Ataulfo mango orchards varied between US$219.67 (± 68.96) and US$1,070.77 (± 267.39) per ha. It is important to note that a relatively large fraction of the producers (58.7%) said they did not know their costs of production, a situation that was especially prevalent in G2 and G3. The production costs were lower than US$800 per ha per year (which is the average production cost) across

Figure 3. Number of Producers per Group, Reasons for Not Being Members of an Association in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico



G2, G3, and G4. Orchards of G5 had the highest production cost.

Production Costs per Orchard per Year (US$)
The highest production costs per orchard were found in G5, followed by G4, G3, and G2.

Production Value per Hectare per Year (US$)
The highest production value per hectare was observed in G3, followed by G5, G4, and G2.

Production Value per Orchard per Year (US$)
The highest production value per orchard was found for G5, followed by G4, G3, and G2.

Profit per Hectare per Year
G2 made lower profits compared to G4, G5, and G3.

Profit per Orchard Per Year
G5 realized the highest profit, followed by G3, G4, and G2.

Profit per Day per Producer
The highest profit per day was noted in G5, followed by G3, G4, and G2.

Profits and Minimum Wages
In 2022, the daily minimum wage in the State of Chiapas was MX$172.87 (US$8.61) (Secretaría del Trabajo y Previsión Social [STPS], 2022). The average profit of G3, G4, and G5 corresponded to multiples of the minimum wage of 9.50, 8.55, and 12.32 per producer per day, respectively. In G1 and G2, daily profit per producer was lower than the minimum wage: 0.50 and 0.89, respectively.

Discussion

The collection of data through producer interviews (N = 126) allowed us to construct groups of Ataulfo mango producers in the Soconusco and Istmo-Costa regions. Hanemann et al. (2008) published a characterization of the region that was based on the size of Ataulfo mango orchards. Our research, however, presents the first research effort to characterize the producers of this region by taking into account their capital reserves.

Using cluster analysis, we identified five different producer groups. In total, 92 producers (73%) were not members of any organization. Most of the producers of G2 and G3 had no membership of any producer organization or association (n = 85, 82.5%). G4 and G5, however, were members of associations (21 producers, 16.7% of the total number). G1 comprised only two producers, one with membership in an organization and the other not. Although very few producers were included in this group, we preferred not to exclude it from the research because its heterogeneity of association strategies for production and marketing may represent potentially emerging producers who merit a specific study.

Table 4. Statistical Comparison of Groups of Ataulfo Mango Producers with Respect to Variables Related To Costs, Value, and Profits of Production in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

	Chi-square test [a]		
Variable	χ^2	df	*P*
Production costs per ha	35.07	9	<0.001
Production costs per orchard	15.27	6	0.018
Production value per ha	14.64	6	0.023
Production value per orchard	48.36	3	<0.001
Profit per ha	11.82	6	0.066
Profit per orchard	20.07	6	0.002
Profit per day per producer	14.60	3	0.002
Profits and minimum wages	22.19	6	0.001

[a] Chi-square contingency tables ($\chi 2$) were generated to determine differences between producer groups. G1 was excluded from the analysis due to its small size (n = 2) of producers.

Producer associations offer many advantages to their member producers, such as the sharing of information and new production skills, access to markets, and the marketing of value-added products (Astudillo-Miller et al., 2020; Sánchez Osorio & Prado Ramírez, 2019; Velázquez & Torres, 2019). And yet, remarkably, Ataulfo mango producers of the Soconusco displayed a profound disinterest in organizing themselves into associations. Similar observations have been made about mango producers in Indonesia (Rasmikayati et al., 2020), Kenya (Muthini et al., 2017), Bangladesh (Kok et al., 2021) and Burkina Faso (Parrot et al., 2022).

"I don't like it" was the most frequently encountered argument from nonmember producers against joining an organization. This response reflects past bad experiences many of the producers may have had when they were affiliated with a producer association. Such distrust in associations makes those other reasons for not joining—such as lack of time, high workload—take on importance. Developing awareness-raising initiatives is a necessary step toward regaining trust in the organizations. Nugussie (2010) found that such initiatives improve producer participation in and their perception about cooperatives. As they regain their trust in these organizations, Chaddad and Iliopoulos (2013) report, producers will come to accept the fixed and variable costs sustained by such organizations, as well as the expenses to organize assemblies for collective decision-making.

Our results suggest that organizational processes (social capital), and the producer's economic situation (financial capital) are largely determined by how producers recognize the emergence or existence of opportunities and exploit them (Chaddad & Iliopoulos, 2013; Czapiewska, 2021; Rondot & Collion, 2001). These opportunities would have allowed the producers to run their orchards more efficiently and include, but are not limited to, the acquisition of new land to enlarge the orchard, association with other producers (Astudillo-Miller et al., 2020; García, 2000), acquiring new technical knowledge, investing in the agronomic management of the orchard, saving or investing part of their earnings, access to financing, and income diversification (Guien Chay et al., 2019; Muthini et al., 2017). For example, several high-yield mango growers reported performing post-harvest pruning to maintain a suitable tree canopy structure. Another grower used rejuvenation pruning combined with canopy pruning of Ataulfo mango trees to interplant them with improved varieties of the same Ataulfo mango (e.g., Citlali or Diamante) or pollen-donor mango trees (e.g., native or creole trees, Tommy or Kent) to improve Ataulfo mango fruiting. In another case, two growers said they adopted high-density planting systems (400 trees per hectare), which, although more difficult to maintain, produce high yields. Some growers also indicated that using drones for foliar applications of agrochemicals was more efficient and precise than using airplanes or tractor-mounted sprayers. In addition, some growers stated that they apply plant growth regulators (such as paclobutrazol) to induce or synchronize fruit production during periods of higher market prices.

In this sense, differences in capital reserves can be understood as sources of competitive advantage. For example, social capital derived from organizational membership allows producers in G4 and G5 to access technical assistance, negotiate collectively, and reach export markets. These advantages align with previous studies that highlight how collective action increases market competitiveness and reduces transaction costs in rural economies (Czapiewska, 2021; Rondot & Collion, 2001).

Reports from other countries have discussed differences in social and financial capital among mango producers. In Indonesia, Kenya, and Bangladesh, for example, a low rate of participation in associations—a social capital variable—negatively affected the marketing and buying of supplies (Kok et al., 2021; Muthini et al., 2017; Rasmikayati et al., 2020). In Bolivia (Aparicio & Díaz, 2015) and Ethiopia (Teka et al., 2019; Neguse et al., 2019), a lack of market information and poor orchard management skills hurt producers' financial capital. Financial capital variables, such as the lack of access to sources of financing and financial technical support, and the loss of revenue due to fungal damage to flowers and fruit, post-harvest fruit deterioration, or sudden drops in market prices reduced the resources available for reinvestment in

mango orchard maintenance in Benin, Burkina Faso, and Ghana (van Melle & Buschmann, 2013). In the study region, similar financial vulnerabilities were observed among nonmember producers, who faced severe crop losses during off-season windstorms. These producers were unable to recover production costs because most lacked crop insurance or access to emergency credit, and they were forced to reduce orchard maintenance in the following season.

G3, G4, and G5 emerged from our economic analysis as the groups with the highest daily profits. Using the daily minimum wage in the State of Chiapas as a reference (MX$172.87 or US$8.61 per day in 2022; STPS, 2022), the profits of G3 (US$81.81), G4 (US$73.62), and G5 (US$106.13) corresponded to multiples of the minimum wages of 9.50, 8.55, and 12.32 per producer per day, respectively. However, the daily profit per producer in the two other groups was much lower than one multiple of the minimum wage: 0.50 (US$4.30) and 0.89 (US$7.32) in G1 and G2, respectively. According to these data, 41% of Ataulfo mango producers in the region had an income less than the minimum wage. Similarly, studies from Indonesia and Ethiopia show that mango producers have low profitability and limited economic returns, despite being active in well-established production regions (Guien Chay et al., 2019; Sulistyowati et al., 2015). This pattern is consistent with our results in Chiapas and mirrors reduced income in smallholder mango production, where limited profitability constrains reinvestment and contributes to persistent productivity gaps.

Such differences also reveal distinct competitive advantages across producer groups. G3 achieved high profitability by focusing on the national market, even without organizational membership, while G4 and G5 leveraged their association-based networks to gain access to technical knowledge, financing, and international buyers. As Porter's theory of competitive advantage suggests, farmer groups may achieve superior performance either through cost advantages or through differentiation in product quality and market access (Porter, 1980; see also Chaddad & Iliopoulos, 2013, for applications in agricultural cooperatives and Sumuano-Barragán et al., 2024, for the value network of the Ataulfo mango in Southern Chiapas).

Analysis of the higher profit groups showed that G3 consisted of a majority of nonmember producers, whereas G4 and G5 were composed of producers who belonged to an organization. Hence, financial capital reserves (income, savings, access to credit, or investment) are strengthened, but not limited, if producers join an association (social capital). Fruit marketing was a key factor that differentiated high-profit in G3 (55 producers, 43.7% of the interviewees) from low-profit G2 (48 producers, 38.1% of the interviewees). The former group sold their mangoes into the national market, while the latter sold them into the local market.

No statistical difference was observed in profits between G3 and G5. However, the mango marketing model and operating methods of the producers of G5 show the potential of export markets as a means to improve profitability. For example, the positive impact of exporting on the income of members of G5, which comprised only exporting producers, stood in stark contrast with the low income of producers of G2 and G3, which comprised 4% and 38% exporting members, respectively. However, as was also observed in Indonesia (Sulistyowati et al., 2015), profit generation through exports in G5 was only within the reach of a small number of producers who were organized in business-like associations (9 producers, 7.1% of the interviewees). Compared to producers of G3, the entrepreneurial character of G5 provided opportunities to its member producers that enabled them to run larger (in terms of area) and to possess greater financial capacity.

However, other forms of mango marketing that can increase the profits of lower-income Ataulfo mango producers in the Soconusco are still in need of exploration. For example, mangoes can be industrially processed to create added-value products, such as mango puree, juice, nectar, wine, frozen mango chunks, dehydrated mango, marmalade, gelatines, pickled mango, or canned mango, as has been shown by mango producers in Burkina Faso (Parrot et al., 2022). As mango producers in Haiti demonstrated (Hyppolite et al., 2013), marketing opportunities also arise from integrating other value chains and from certified organic production. Organic certification could be a viable

option for Ataulfo mango producers in the Soconusco and Istmo-Costa regions. Not only does organic certification guarantee the health of the system, but it also opens new market opportunities to obtain better prices and to create a valued product that is recognized nationally and internationally.

Overall, our findings show that competitive advantages among Ataulfo mango producers emerge from different pathways: through market orientation as G3, through collective organization and access to external resources as G4 and G5, or through a combination of both. By linking capitals to competitive advantage, this study highlights that profitability and sustainability are not determined solely by orchard size or yields, but rather by how producers mobilize their human, social, and financial resources within the value chain. Similar dynamics have been reported in mango sectors of Kenya and Indonesia, where organizational membership or innovative marketing channels shaped producers' competitiveness (Muthini et al., 2017; Rasmikayati et al., 2020).

Conclusions

This study aimed to characterize Ataulfo mango producers in the Soconusco and Istmo-Costa regions of Chiapas, Mexico, through the lens of their social, human, and financial capital. By moving beyond conventional agronomic variables and yield-focused analyses, we uncovered the systemic inequalities and resource asymmetries that shape the economic trajectories of smallholder mango producers in a region with high export potential. Inequalities refer to measurable differences among producers in access to resources, market opportunities, income, orchard size, and organizational membership, which collectively affect their economic outcomes.

While they represented only a fifth of our sample, producers who were members of associations occupied the best positions in the production and marketing of mango. We found that technical support, selling into international markets, diversified sources of financing and income sources, effective bookkeeping, saving a portion of profits, and adopting agroecological practices were more common in member producers.

Although it is commonly believed that a lack of organization compromises producer viability, our results indicate that one of the groups (G3, intermediate commercial producers), mainly composed of nonmember producers, achieved remarkably healthy profitability levels. This contradiction shows us that some nonmember producers have independently developed successful financial management and marketing strategies. While membership in a producer association can serve as a starting point for improvement and provide various benefits, it alone does not guarantee greater profitability, even though organized producers generally have greater financial and social capital than nonmembers.

While some challenges remain, such as the reluctance to join an association, lack of time, or unawareness of its benefits, our findings suggest that the decision to not associate with an organization did not necessarily have an adverse impact, as some producers were successful even without being members of an organization.

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Appendix

Table A1. Key Leverage Variables that Defined the Names of Ataulfo Mango Producer Groups in Chiapas, Mexico

Variable	G1 Packing-linked producers (*n* = 2)	G2 Resource-limited producers (*n* = 48)	G3 Intermediate commercial producers (*n* = 55)	G4 Multi-market producers (*n* = 12)	G5 Export-specialized producers (*n* = 9)
Mean orchard size (ha ± SE)	16.75 ± 3.42	2.86 ± 0.34	8.89 ± 1.46	20.6 ± 8.02	43.44 ± 12.70
Orchard size distribution	1–10 ha: 50% 11–30 ha: 50% ≥31 ha: 0%	1–10 ha: 87.5% 11–30 ha: 10.4% ≥31 ha: 2.1%	1–10 ha: 81.8% 11–30 ha: 12.7% ≥31 ha: 5.5%	1–10 ha: 50.0% 11–30 ha: 16.7% ≥31 ha: 33.3%	1–10 ha: 33.3% 11–30 ha: 11.1% ≥31 ha: 55.6%
Producer's education [a]	NF: 0.0% ES: 0.0% MS: 0.0% HS: 0.0% UN: 100% GE: 0.0%	NF: 2.1% ES: 45.8% MS: 29.2% HS: 18.8% UN: 4.2% GE: 0.0%	NF: 3.6% ES: 29.1% MS: 16.4% HS: 16.4% UN: 32.7% GE: 1.8%	NF: 0.0% ES: 25.0% MS: 0.0% HS: 8.3% UN: 50.0% GE: 16.2%	NF: 0.0% ES: 0.0% MS: 22.2% HS: 0.0% UN: 77.8% GE: 0.0%
Organization membership	Yes: 50% No: 50%	Yes: 18.7% No: 81.3%	Yes: 16.4% No: 83.6%	Yes: 75.0% No: 25.0%	Yes: 66.7% No: 33.3%
Mean profit per ha (US$ ± SE)	448.43	1,293.86 ± 218.66	3,309.18 ± 611.70	2,677.93 ± 608.37	2,619.03 ± 841.20
Mean profit per orchard (US$ ± SE)	1,569.50	2,800.07 ± 461.04	29,875.20 ± 13,165.07	26,872.82 ± 9,522.06	38,720.72 ± 11,684.45
Technical assistance	Yes: 50% No: 50%	Yes: 2.1% No: 97.9%	Yes: 27.3% No: 72.7%	Yes: 41.7% No: 58.3%	Yes: 100% No: 0.0%
Type of market [b]	LM: 0.0% NM: 50.0% IM: 50.0%	LM: 77.1% NM: 47.9% IM: 4.2%	LM: 56.4% NM: 87.3% IM: 41.8%	LM:25.0% NM: 66.7% IM: 66.7%	LM: 0.0% NM: 55.6% IM: 100.0%
Use of packing facilities as a commercialization channel	100% use packing facilities for national and international commercialization.	0% use packing facilities; commercialization limited to local markets.	41.8% international markets via indirect use of packing facilities.	66.7% use packing facilities for national markets and 66.7% for international markets.	100% use packing facilities for international markets; 55.6% also participate in national markets.

[a] NF= non-formal education; ES= elementary school; MS= middle school; HS: high school; UN= university; GE: graduate education.
[b] LM= local market; NM= national market; IM= international market.

Table A2. Number of Producers per Group and per Variable of Human Capital in Ataulfo Mango Orchards in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

Variable	Producer groups [a]					
	G1 [b]	G2	G3	G4	G5	χ^2; df; *P*
Gender						
Men	2	42	49	12	8	1.66; 3; 0.653
Women	0	6	6	0	1	
Age						
≤ 59	2	15	21	7	4	3.19; 3; 0.362
≥ 60	0	33	34	5	5	
Level of schooling						
Non	0	1	2	0	0	44.44; 18; <0.001
Primary	0	22	16	3	0	
Secondary	0	14	9	0	2	
Highschool	0	9	9	1	0	
University	2	2	18	6	7	
Master´s	0	0	0	1	0	
Doctorate	0	0	1	1	0	
Number of children who help their parents in the orchard						
0	1	29	37	6	4	4.63; 6; 0.590
1	1	17	14	4	4	
2–4	0	2	4	2	1	
Number of people living at home						
1–2	0	15	18	5	3	4.01; 9; 0.910
3–4	2	22	22	4	5	
5–6	0	9	14	2	1	
≥ 7	0	2	1	1	0	
Health status						
Good	2	17	26	6	5	6.43; 6; 0.376
Fair	0	28	29	6	4	
Poor	0	3	0	0	0	
Knowledge and implementation of agroecological strategies						
Yes	1	0	4	2	3	18.21; 4; <0.001
No	1	48	51	10	6	

[a] G1, packing-linked producers (2 producers, 1.6%), G2, resource-limited producers (48 producers, 38.1%); G3, intermediate commercial producers (55 producers, 43.7%); G4, multimarket producers (12 producers, 9.5%); and G5, export-specialized producers (9 producers, 7.1%).

[b] G1 was excluded from all chi-square and correspondence analyses due to its small size of producers (n = 2).

Table A3. Number of Producers per Group and per Variable of Social Capital in Ataulfo Mango Orchards in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

Variable	Producer groups [a]					χ^2; df; *P*
	G1 [b]	G2	G3	G4	G5	
Importance of mango in the household economy						
High	1	29	35	6	8	15.33; 9; 0.082
Moderate	1	12	17	4	1	
Low	0	7	3	1	0	
Negligible	0	0	0	1	0	
Homeownership						
Yes	2	47	51	12	7	6.77; 3; 0.79
No	0	1	4	0	2	
Membership of an organization						
Yes	1	9	9	9	6	26.25; 3; <0.001
No	1	39	46	3	3	
Technical assistance						
Yes	1	1	15	5	9	43.27; 3; <0.001
No	1	47	40	7	0	
Had received technical assistance						
Yes	1	2	20	8	9	43.70; 3; <0.001
Never	1	46	35	4	0	

[a] G1, packing-linked producers (2 producers, 1.6%), G2, resource-limited producers (48 producers, 38.1%); G3, intermediate commercial producers (55 producers, 43.7%); G4, multi-market producers (12 producers, 9.5%); and G5, export-specialized producers (9 producers, 7.1%).

[b] G1 was excluded from all chi-square and correspondence analyses due to its small size of producers (n = 2).

Table A4. Number of Producers per Group and per Variable of Financial Capital in Ataulfo Mango Orchards in the Soconusco and Istmo-Costa Regions of Chiapas, Mexico

Variable	Producer groups [a]					χ^2; df; *P*
	G1 [b]	G2	G3	G4	G5	
Tracking production costs						
Yes	1	1	8	11	4	53.81; 3; <0.001
No	1	47	47	1	5	
Saving or investing						
Yes	1	5	11	8	5	22.60; 3; <0.001
No	1	43	44	4	4	
Percentage of savings						
5–10	0	1	7	2	1	6.27; 6; 0.393
15–20	0	3	3	3	2	
25–50	1	1	1	3	2	
Sources of financing						
Bank loans	0	1	0	0	1	41.96; 15; <0.001
Government loans	0	1	0	1	2	
Family	0	18	35	8	2	
Mixtures	0	0	0	1	1	
None	0	27	20	2	3	
Other	2	1	0	0	0	
Insurance						
Agricultural	0	0	0	0	0	54.48; 12; <0.001
Life	0	1	1	2	1	
Major medical expenses	0	0	0	1	0	
Mixtures	0	0	0	1	1	
Social security	0	0	0	0	2	
None	2	47	54	8	5	
Sources of income						
Mango sales	1	4	5	0	1	16.44; 9; 0.058
Mango sales + other income	1	34	33	8	7	
Mango sales + 2 additional incomes	0	9	17	2	0	
Mango sales + 3 additional incomes	0	1	0	2	1	
Ways of selling the harvest						
Box	2	2	26	8	8	40.21; 3; <0.001
Orchard	0	46	29	4	1	

Table A4 continued

Table A4 continued

Sales market						
Local	0	23	7	0	0	73.73; 18; <0.001
National	1	7	7	1	0	
International	1	0	2	2	4	
Local, national	0	14	20	3	0	
National, international	0	2	15	4	5	
Local, national, international	0	0	4	2	0	
Unsure	0	2	0	0	0	
Buyers						
Orchard intermediary	0	46	30	4	0	78.03; 15; <0.001
Box intermediary	0	1	10	0	0	
Packing house	2	1	12	6	6	
National supply center	0	0	2	1	1	
Regional markets	0	0	0	1	0	
International intermediary	0	0	1	0	2	
Income from mango harvest per ha (US$)						
≤ $3,086	1	40	22	8	6	25.00; 9; <0.002
$3,087–$6,179	0	4	14	2	3	
≥ $6,180	1	2	14	1	0	
Unsure	0	2	5	1	0	
Cost of production per ha (US$)						
≤ $249	0	8	5	1	0	35.07; 9; <0.001
$250–$998	1	3	12	7	3	
≥ $9,991	0	0	7	2	3	
Unsure	1	37	31	2	3	
Daily income (US$)						
< $3.74	0	1	0	0	0	69.67; 15; <0.001
$3.75–$7.48	2	41	23	2	1	
$7.49–$11.22	0	5	16	3	3	
$11.23–$14.97	0	0	7	0	0	
$14.98–$18.71	0	1	5	1	0	
> $18.72	0	0	4	6	5	

[a] G1, packing-linked producers (2 producers, 1.6%), G2, resource-limited producers (48 producers, 38.1%); G3, intermediate commercial producers (55 producers, 43.7%); G4, multi-market producers (12 producers, 9.5%); and G5, export-specialized producers (9 producers, 7.1%).

[b] G1 was excluded from all chi-square and correspondence analyses due to its small size of producers (n = 2).

Table A5. Number of Producers and Average (±standard error) of the Economic Analysis Variables by Group in Ataulfo Mango Orchards in Soconusco and Istmo-Costa Regions of Chiapas, Mexico

Range of variables (US$)	Producer groups [a]					
	G1 [b]	G2	G3	G4	G5	χ^2; df; *P*
Production costs per ha (US$)						
≤ $249	0	8	5	1	0	35.07; 9; <0.001
$250–$998	1	3	12	7	3	
≥ $9991	0	0	7	2	3	
Unsure	1	37	31	2	3	
Mean± standard error	596.57	219.67± 68.96	794.33± 146.94	$720.94± 139.89	1,070.77± 267.39	
Production costs per orchard (US$)						
≤ 5,000	1	11	17	4	2	15.27; 6; 0.018
$5,001- $25,000	0	0	5	3	1	
≥ $25,001	0	0	2	3	3	
Mean± standard error	2,095.13	532.46± 127.11	6,516.57 ± 2,535.48	20,884.63± 12,703.50	43,506.31± 22,213.64	
Production value per ha (US$)						
< $2,500	1	40	31	7	4	14.64; 6; 0.023
$2,501 - 5,000	0	4	9	3	4	
>$5,001	1	2	10	1	1	
Mean± standard error	3,505.23± 2,458.89	1,634.14± 243.25	4,081.97± 477.04	2,625.52± 526.75	2,974.35± 614.70	
Production value per orchard (US$)						
< $21,225	1	46	40	4	1	48.36; 3; <0.001
>$21,226	1	0	10	7	8	
Mean± standard error	91,292.97± 87630.79	3,826.15± 584.53	22,949.01± 7,720.28	42,291.07± 11,267.69	72,548.99± 13,025.64	
Profit per ha (US$)						
≤ $2,500	1	11	11	4	3	11.82; 6; 0.066
$2,501 - 5,000	0	0	5	3	1	
≥$5,001	0	0	8	1	1	
Mean± standard error	448.43	1,293.86± 218.66	3,309.18± 611.70	2,677.93± 608.37	2,619.03± 841.20	
Profit per orchard (US$)						
≤ $7,500	1	11	12	2	0	20.07; 6; 0.002
$7,501 - 15,000	0	0	5	1	1	
≥$15,001	0	0	7	5	4	
Mean± standard error	1,569.50	2,800.07± 461.04	29,875.20± 13,165.07	26,872.82± 9,522.06	38,720.72± 11,684.45	

Table A5 continued

Table A5 continued

Profit per day per producer (US$)						
≤ $60	1	11	18	3	1	14.60; 3; 0.002
≥$61	0	0	6	5	4	
Mean± standard error	4.29	7.66± 1.26	81.81± 36.02	73.62± 26.08	106.08± 32.01	
Profits and minimum wages (US$)						
≤ 1	1	9	8	2	0	22.19; 6; 0.001
1.1 - 5	0	2	11	1	1	
≥5.1	0	0	5	5	4	
Mean± standard error	0.50	0.89± 0.15	9.50± 4.19	5.55± 3.03	12.32± 3.72	

[a] G1, packing-linked producers (2 producers, 1.6%), G2, resource-limited producers (48 producers, 38.1%); G3, intermediate commercial producers (55 producers, 43.7%); G4, multi-market producers (12 producers, 9.5%); and G5, export-specialized producers (9 producers, 7.1%).
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Opportunity costs and agricultural transformation in the Ecuadorian Amazon: Cacao cultivation in traditional Shuar systems

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Abstract

This study analyzes the socioeconomic dynamics and land-use practices of small-scale Shuar farmers in Taisha, Tuutinentsa, and Macuma, in the Ecuadorian Amazon. Based on surveys of 43 cacao producing households, we analyzed perceptions of well-being, land allocation, and livelihood diversification. Households typically include five to six members and rely on diversified portfolios com-

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bining cacao (*Theobroma cacao* L.), peanuts (*Arachis hypogaea* L.), plantain (*Musa* × *paradisiaca* L.), livestock, forest, and off-farm activities. Gendered labor divisions are present: men are more involved in marketed production and commercialization, while women play central roles in chakra-based agroforestry management, food provisioning, and household economies that reduce cash expenditures and strengthen food sovereignty. Average farm sizes range from 31 to 40 hectares, with forest and pasture, with smaller areas allocated to perennial and short-cycle crops. These patterns reflect multifunctional strategies balancing income generation, risk management, cultural continuity, and environmental stewardship rather than single-crop optimization. Agriculture and livestock constitute the main income sources in Taisha and Tuutinentsa, whereas Macuma exhibits greater economic diversification due to proximity to urban markets. High transportation costs and limited infrastructure constrain profitability. Reported cacao yields are lower than provincial and national averages; however, chakra-based systems prioritize multiple outputs beyond yield, including food security, ecosystem services, and cultural values. Opportunity cost analysis suggests higher short-term returns for peanuts, while cacao remains central due to its larger cultivated area. These findings highlight the complexity of Indigenous agriculture and the need for culturally grounded development policies aligned with socio-ecological realities.

Keywords
Indigenous agriculture, land use, rural economy,

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forest conservation, socioeconomic well-being, Ecuador, Amazon

Introduction and Literature Review

Indigenous peoples represent approximately 6% of the world population, totaling 476 million individuals (Organización Internacional del Trabajo, 2019), and occupy approximately 32% of the world's forests (Fa et al., 2020). Indigenous communities' land use, particularly in the Amazon Basin where vast areas remain under Indigenous governance, is central to forest conservation, territorial autonomy, and cultural heritage preservation (Gray & Bilsborrow, 2020).

The Shuar are an Indigenous group of approximately 110,000 people distributed across Peru and Ecuador. In Ecuador, they inhabit six Amazon provinces, with major concentrations in Zamora Chinchipe and Morona Santiago. These communities display varying degrees of market access and integration in the cash economy (De Salvador-Agra & Martínez-Suárez, 2015; Liebert et al., 2013; Urlacher et al., 2016).

Shuar subsistence is based on agriculture, fishing, and hunting in a cultivation model that combines food production, ecological management, and cultural adapted practices. Main crops include corn (*Zea mays* L.), cassava (*Manihot esculenta*), plantain (*Musa AAB Simmonds*), beans (*Vigna unguiculata* L.), sweet potatoes (*Ipomoea batatas* L.), and peanuts (*Arachis hypogaea* L.) (Confederación de Nacionalidades Indígenas del Ecuador, n.d.). However, some communities have reduced staple crops areas in favor of market-oriented crops such as coffee (*Coffea canephora*) and cacao (*Theobroma cacao* L.), alongside expanded livestock grazing (Gray & Bilsborrow, 2020).

Frequent interaction with oil and mining companies has also reshaped livelihoods, with many members employed in extractive industries (Confederación de Nacionalidades Indígenas del Ecuador, 2023). Contact with religious groups, settlers, the state, and corporations has produced adaptations in Shuar life, including the adoption of monetary system and formal education, sometimes resulting in impoverishment and acculturation (Paño et al., 2020).

Ecuador's decentralization process established Decentralized Autonomous Governments (GADs) at provincial and cantonal levels. In the Amazon, several GADs promote agricultural value chains, including cacao, supporting activities from nurseries to post-harvest processing with chakra. These efforts have taken place in the context of Indigenous communities' chakra-based subsistence farming systems practices, which shape local agricultural practices and livelihood strategies in the study area. The chakra is an ancestral production system used by Indigenous peoples. It is based on the use of traditional knowledge and the sustainable management of natural resources. It is practiced on small plots of land with diversified crops intended for food, traditional medicine, and other uses, contributing both to food security and to the generation of family income (Bredero et al., 2023; Food and Agriculture Organization of the United Nations [FAO], 2023; Vera et al., 2020).

Although Ecuador is a major cacao producer and exporter, it has historically focused on raw cacao beans (Nieto & Caicedo, 2012; Villacís et al., 2022). Public policies now seek to promote social and productive development in the Ecuadorian Amazon Region (EAR), emphasizing sustainable livelihoods, value-chain strengthening, and cultural identity through instruments such as the National Development Plan (Secretaría Nacional de Planificación, 2021), the Organic Law on the Special Territorial Circumscription of the Amazon (Asamblea Nacional del Ecuador, 2018), and local life plans (Gobierno Autónomo Descentralizado Municipal del Cantón Taisha, 2014).

Globally, the top cacao producer countries are Ivory Coast, Ghana, and Ecuador (International Cocoa Organization, 2024). The coastal provinces of Los Ríos, Guayas, Manabí, and Esmeraldas cultivate 90% of Ecuador's cacao, and the most prominent varieties are "Fino de Aroma" and "CCN-51" (Cedeño & Dilas, 2022; Vargas et al., 2016). However, the eastern provinces of Ecuador Sucumbíos, Orellana, Napo, Pastaza, Morona Santiago, and Zamora Chinchipe, referred to as the Ecuadorian Amazon Region (EAR), makes up 45% of the national territory but contribute only approximately 10% of the cacao nacional (*Theobroma cacao* L. "Nacional," a traditional Ecuadorian fine-flavor genotype) output (Caicedo-

Vargas et al., 2022; Instituto Nacional de Estadística y Censos, 2017). Production in the EAR is dominated by small and medium-sized farmers using agroforestry chakras that provide ecosystem services such as climate regulation and biodiversity conservation, though they are primarily oriented toward subsistence and local markets (Filho et al., 2014; Jadán, 2012; Niether et al., 2020).

Incorporating cacao into chakra systems has generated socio-economic and ecological changes, including biodiversity shifts and disruptions of traditional practices (Bentley et al., 2004; Rice & Greenberg, 2000). Increased dependence on intermediaries who channel approximately 67% of production has heightened producer vulnerability (Viteri et al., 2023). The region's low productivity and profitability are additional factors affecting the adoption of cacao cultivation. The remuneration received by local small and medium-scale farmers is comparatively lower (55%–60% per pound) than the price paid in Guayas Province—a region with large-scale cacao production—which may be attributed to higher transportation costs, limited markets access, and the reduced bargaining power of farmers in Amazon territories (Caicedo-Vargas et al., 2022). Agriculture and livestock remain the main household activities of in the EAR (Gray et al., 2008; López et al., 2013; Torres et al., 2018; Vasco et al., 2015).

Although chakras ensure food self-sufficiency they often fail to generate sufficient cash income to meet household needs (Caicedo-Vargas et al., 2022). A significant portion of the rural population has opted for non-agricultural and off-farm employment to increase household income and meet basic family needs (Bilsborrow et al., 2004). Vasco et al. (2013) demonstrated that non-agricultural and off-farm employment (e.g., extractive activities and service-based tourism) together represent 36% of household income in rural areas and provides employment to 33% of the local population. These employment types have adversely affected the agricultural sector, leading to land abandonment and a decline in the independent and productive capacity to meet families' needs (Vasco et al., 2013). According to Sellers et al. (2017), a lack of employment and educational opportunities are the primary drivers of migration to nearby urban centers or major cities in the EAR.

Taisha is a canton located in the province of Morona Santiago (within the EAR). According to the latest census, 64% of its economically active population are engaged in agricultural, livestock, forestry, and fishing activities (Gobierno Autónomo Descentralizado Municipal del Cantón Taisha, 2020). A transition from ancestral to commercial production has led to forest conversion into pastures and monocultures (Gobierno Autónomo Descentralizado Municipal del Cantón Taisha, 2014), with approximately 12,000 ha lost between 2000 and 2018 (Beuchle et al., 2022). Agriculture and livestock account for 22% and 44% of family income, respectively (Gobierno Autónomo Descentralizado Municipal del Cantón Taisha, 2014).

GAD's priorities emphasize the promotion of organic production systems aimed at reducing the use of chemical pesticides, which have been widely associated with environmental degradation and adverse human health effects (Hayes et al., 2006; Zheng et al., 2016), including dermatological, gastrointestinal, carcinogenic, and respiratory conditions (Mnif et al., 2011). Within this framework, the development of the cacao national industry represents a strategic opportunity, as cacao can be cultivated under organic and agroforestry-based systems that promote diversity conservation, sustainable land use, and rural livelihoods while also offering significant commercial potential. Expanding cacao production could generate employment opportunities, attract tourism, and stimulate the local economy, particularly given the high international demand for Ecuadorian cacao dried beans (Vargas et al., 2016).

A majority of farmers use an organic production system (i.e., without the use of chemical inputs such as fertilizers and pesticides), where the methods and techniques employed are ancestral (Altieri & Nicholls, 2005; Pretty, 2002). As a result, farmers may not consistently implement crop management practices commonly promoted by extension services, such as regular pruning, systematic harvesting, or manual weed and disease control, nor consistently apply organic fertilizers such as biol, a liquid organic fertilizer produced through the an-

aerobic fermentation of organic materials. These practices are shaped by labor constraints, limited access to inputs, and the subsistence-oriented nature of ancestral production systems, rather than by a lack of traditional knowledge (Altieri, 1999; Gliessman, 2014).

The specific objectives of this study were to: (1) identify the socioeconomic conditions of small-scale farmers from different Shuar communities, (2) analyze comparative advantages through an opportunity cost analysis of different commercial agricultural activities, and (3) determine the role of cacao cultivation in the economic dynamics of Shuar communities.

Applied Research Methods

We used household surveys and field data to examine farming practices, livelihood conditions, and the economic contribution of key agricultural activities in the study communities.

Study Area

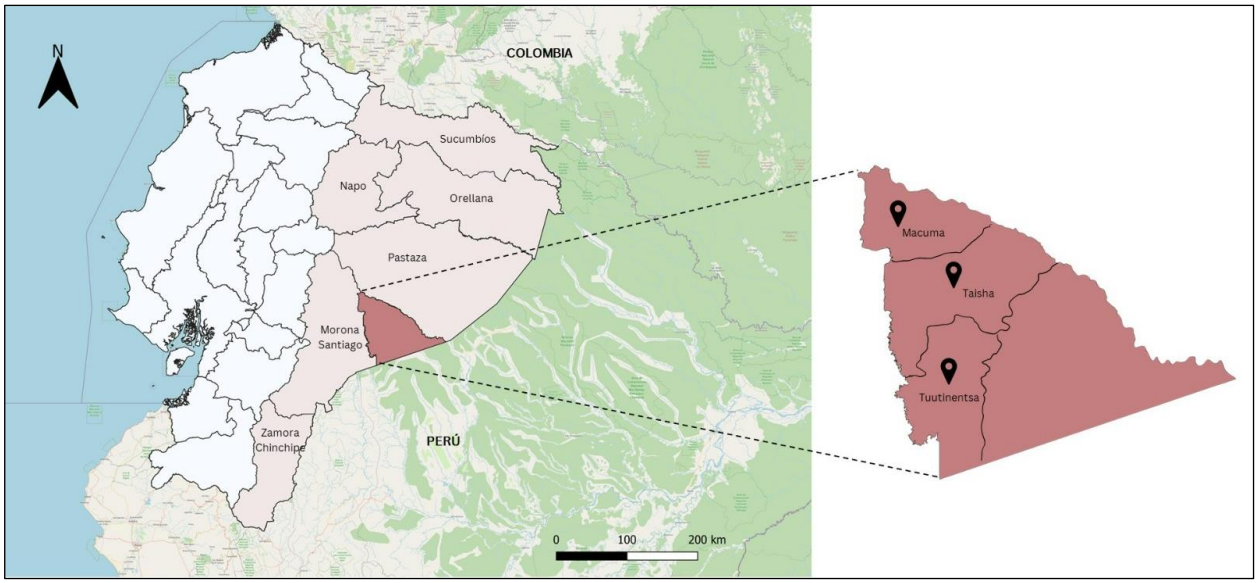
We conducted this study in Taisha Canton, located in the province of Morona Santiago, and collected data in three locations: (1) Taisha (02°30'38.28"S, 77°23'22.26"W), (2) Tuutinentsa (02°30'52.78"S, 77°25'48.91"W), and (3) Macuma (02°9'10.61"S, 77°42'10.53"W) (Figure 1). Taisha Canton covers approximately 6,200 km², accounting for 25.6% of the territory of Morona Santiago province, which is situated in the EAR. The canton has a population of 26,700, of whom 1,864 reside in urban areas. The remaining 24,836 inhabitants live in rural areas (Instituto Nacional de Estadística y Censos, 2022).

Sample Design and Data Collection

We conducted this study over three months (December 2017–February 2018), involving 43 farmers engaged in organic cacao production, representing 10 Indigenous communities (*Amazonas, Jimiaraentza* or *Dos Ríos, Kuamar, Putunza, Shinkiatam, Tintiukentza, Tsentsakentza, Tumpain, Vario Sant,* and *Yaas Nuntsa*). The study was implemented as part of the broader project "Alternatives to Reduce the Use of Pesticides Harmful to Humans and the Environment," which involved 185 farmers participating in training activities related to organic cacao production and the preparation and use of bioles over a 24-month period.

From this project population, we purposively

Figure 1. Location of the Ecuadorian Amazon Region (EAR), Comprising the Provinces of Sucumbíos, Orellana, Napo, Pastaza, Morona Santiago, and Zamora Chinchipe.
The inset highlights the study area in Morona Santiago Province, Ecuador, showing the survey sites in the Indigenous communities of Macuma, Taisha, and Tuutinentsa. Data were collected between December 2017 and February 2018.



selected 43 small-scale farmers for detailed data collection using a geographical cluster sampling approach, grouping communities into three locations (Taisha, Tuutinentsa, and Macuma). We interviewed one member per household to avoid data duplication.

A trained field technician with experience working in rural communities conducted the face-to-face interviews in Spanish; each interview lasted approximately 30 minutes and addressed topics related to the socioeconomic conditions of farming families, agricultural practices, input supply, and crop yields.

Data Analysis

We performed a descriptive analysis of variables using the collected data; the mean was used to measure central tendency, providing the expected or representative value of the population. The standard deviation was used to assess the dispersion of quantitative data.

Finally, we calculated the opportunity cost for producers to assess the comparative advantages of producing cacao, peanuts, plantains, and livestock (Kolinjivadi et al., 2015) using the following formula:

$$VA_{xi} = (I_{xi}/(A_{xi})) - (C_{xi}/(A_{xi}))$$

where the value-added (VA) represent the difference between total income (I) and total cost (C), normalized by the total production area in hectares (A) for each commercial activity (xi). Costs included expenses related to hired labor, transportation for products, commercialization, and the imputed value of family labor. To standardize the valuation of family labor across production systems and ensure comparability between activities, family labor was monetized using the sectoral minimum wage for agricultural workers established by the Ministerio del Trabajo (2019) equivalent to US$395 per month. This approach assumes that the minimum wage represents the baseline opportunity cost of labor in rural areas, reflecting the income that household members could obtain if employed in the local agricultural labor market.

This indicator is used exclusively to compare the cash-income potential of marketed products under the observed production conditions. It does not capture the full opportunity cost of land use within chakra-based or forested systems, where nonmarket values, such as household food provisioning, medicinal resources, cultural continuity, and ecosystem services, are central to livelihood strategies. Therefore, results derived from this metric should be interpreted as partial and contextual rather than prescriptive.

Ethical Considerations, Free, Prior and Informed Consent (FPIC), and Indigenous Data Governance

We conducted this in Shuar Indigenous territories using a participatory approach within an ongoing development project. Prior to data collection, we explained the research objectives, data types, and intended uses (including academic publication) during community workshops and field activities. Participation was voluntary, and we obtained informed consent from all interviewees. We implemented research activities with community knowledge and acceptance through established engagement mechanisms.

In line with principles of Indigenous Data Sovereignty, we anonymized all data and are presenting data only in aggregated form to prevent identification of individuals or households. Although the study predates the formal articulation of the CARE Principles, our data management and dissemination were guided by their core values, emphasizing respect, responsible use of information, and support for locally relevant decision-making. Outputs are available to project partners and participating communities upon request, and no identifiable data are shared beyond the research team.

Additionally, we acknowledge that more recent frameworks, such as the Kichwa–Kara data sovereignty framework and IEEE Standard 2890 on Indigenous data governance, provide important guidance for the stewardship, rematriation, and repatriation of Indigenous data, including legacy datasets. While this study predates the formal adoption of these frameworks, their principles are consistent with the ethical approach followed in this research, and we recognize their relevance for guiding future work in Indigenous contexts (Carroll et al., 2017; IEEE, 2021).

Results

The results provide an overview of the main household and livelihood characteristics observed across the three study communities. They highlight differences in family composition, agricultural activities, income sources, production costs, and opportunity costs that help explain the economic conditions of the surveyed households.

Household Characteristics

Our study findings indicate that the average family size among the surveyed households in Taisha, Tuutinentsa, and Macuma ranges between five and six members, exceeding the national average of 3.8 members per household. The distribution of household sizes shows that families with 1–3 and 4- members represent 23% and 53% of the sample, respectively, while those with 7–9 and more than 10 members account for only 12% and 9%, respectively (Pichon, 2005). All surveyed households were categorized as biparental families with children (i.e., head of household, spouse, and children). The average age of the farmers interviewed was 48 years, with 23.3% being women and 76.7% men (Table 1). Women play central roles in chakra-based agroforestry management, food provisioning, child-rearing, and household economies, contributing substantially to food security and the reduction of cash expenditures (Coq-Huelva et al., 2017). We therefore avoid framing the work of women in the chakra as outside the economy; rather, it constitutes a foundational component of household livelihoods and biocultural continuity.

Land Tenure and Land Use

The land owned by Indigenous farmers is of communal origin, meaning that formal land titles are held collectively by the community rather than by individual households. In practice, however, these communal lands are subdivided into individual managed family plots, where each household is responsible for cultivation and production decisions, while land ownership and governance remain under collective community authority. Farms are often subdivided due to inheritance distribution among offspring, land exchange for livestock, or sales to settlers or mestizo migrants from the mountainous or coastal regions of the country.

The average land area in the three study sites is 31.1, 33.6 and 40.4 ha, respectively (Table 1). These farms are characterized by a larger proportion of forested areas (46%-70%) and pastures (20%-40%), while only a smaller share is allocated to short-cycle and semi-perennial crops such as cacao (4%-7%), subsistence crops (2%-5%), plantains, and peanuts (<1.7%), reflecting diversified land-use strategies that prioritize forest conservation, livelihood resilience, and household provisioning rather than the maximization of single-crop area.

Another notable trend is that Amazonian farmers are focusing increasingly on forest conservation and farm diversification, by integrating annual, short-cycle, perennial crops, and small-scale livestock production. Timber from the forest is mainly used for house construction and not for commercial purposes. Pastures occupy a significant portion of the land but remain underutilized. In at least two of the studied localities, we observed an average stocking density of 0.34 animals per hectare.

Socioeconomic Analysis

The primary source of income in Taisha and Tuutinentsa is derived mainly from agricultural activities, whereas Macuma shows a more diversified income structure linked to off-farm employment, including grocery sales, domestic services, public-sector employment, artisanal crafts, and construction work. This pattern may be partly explained by Macuma's closer proximity to the provincial capital, Macas (approximately 72 km or 45 miles), and its relatively better road access, which likely facilitate greater integration into non-agricultural labor markets.

Income generated from economic activities varies depending on the characteristics of each community. In Macuma, off-farm employment contributes 62%, placing agricultural income in a secondary position (38%). In Taisha, however, 70% of household income is generated from agricultural and livestock activities, and as it serves as the canton's administrative center, off-farm employment contributes 30%, which is higher than in Tuutinentsa, which is the only community where 100% of income is derived from agricultural and livestock activities (Figure 2). The lowest income

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Table 1. Descriptive and Summary Statistics Characterizing Social, Farm, and Income at Taisha, Tuutinentsa, and Macuma, Morona Santiago, Ecuador

Data collected from December 2017 to February 2018.

		Statistics											
		Taisha (*n* = 20)				Tuutinentsa (*n* = 8)				Macuma (*n* = 15)			
Variable	Description	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max
Social characteristics													
Age	Age of the surveyed (years)	50	(11.4)	23	68	51	(12.5)	30	66	42	(12.4)	22	63
	20–40 [a]	30				25				33			
	41–60 [a]	55				50				60			
	>61 [a]	15				25				7			
Gender	Gender participation [a]												
	Female	20				13				33			
	Male	80				87				67			
Household size	Number of people	5	(1.72)	2	8	5	(3.60)	2	13	6	(3.7)	2	14
	1–3 [a]	25				38				13			
	4–6 [a]	55				38				67			
	7–9 [a]	20				12				0			
	>10 [a]	0				12				20			
Farm characteristics													
Farm	Total land area [b]	31.1	(26.3)	1	100	33.6	(37.9)	1	120	40.4	(23.3)	5	85
Cacao	Land area under production	1.17	(0.74)	0.36	2.50	1.99	(1.50)	0.39	5	1.56	(0.97)	0.30	3.50
Peanut	Land area under production [b]	0.90	(1.93)	0.10	7	0.19	(0.09)	0.06	0.25	0.12	(0.12)	0.01	0.25
Plantain	Land area under production [b]	0.74	(0.60)	0.05	2	0.86	(0.92)	0.01	3	1.27	(1.31)	0.06	5
Livestock	Number of cattle per family	7	(6.39)	2	22	4	(3.06)	1	7	11	(14.4)	2	43
Income characteristics													
Opportunity cost	Cacao production [c]	368	(614)			327	(927)			439	(468)		
	Peanut production [c]	1961	(192)			1984	(484)			2056	(141)		
	Plantain production [c]	714	(676)			318	(68.4)			168	(191)		
	Cattle production [c]	55.9	(38.2)			68.9	(46.1)			485	(575)		
Agricultural	Average net income [e]	2306	(935)	651	4204	1834	(1228)	154	2975	1221	(1028)	224	3256
Livestock [d]	Average net income [e]	1239	(1639)	150	5200	1404	(614)	696	1797	2035	(1336)	755	4460

SD = Standard deviation in parenthesis. [a] Percentage (%); [b] Hectare (ha); [c] Dollar per hectare (US$ ha^{-1}); [d] Cattle, pigs, and poultry; [e] Dollar per family per year

levels are in Tuutinentsa, as it is the most remote community in the canton, restricting the travel of its residents mainly to crop sales and health emergencies. Furthermore, this isolation hinders interpersonal relationships between Indigenous people and settlers, reducing opportunities to build social networks and access information about employment opportunities in urban areas.

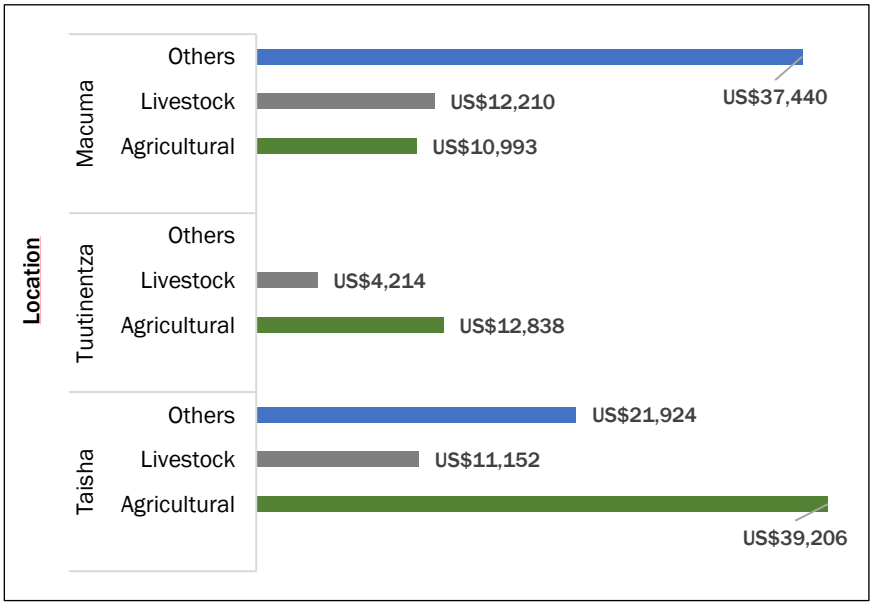
When we asked farmers which crops generated the highest income, they identified three commercial crops (cacao, peanuts, and plantain), along with a fourth income source derived from the sale of cattle. We quantified income from agricultural activities for each community, showing that the agricultural sector contributes, on average per family (household), US$2,306, US$1,834 and US$1,221 per year in Taisha, Tuutinentsa, and Macuma, respectively. We calculated these values based on the yield of commercial crops (e.g., cacao, peanuts, plantain, and pasture), minus the production and marketing costs of each crop. The price for cacao and peanuts is set by Fundación Chankuap (n.d.), while the price of plantains is determined by the local market. Similarly, the livestock sector contributes, on average, US$1,239, US$1,404 and US$2,035 per family per year in Taisha, Tuutinentsa, and Macuma, respectively. Wecalculated these values based on the sale of various animals raised and sold on the farm (e.g., cattle, poultry, and pigs), minus production costs. The relatively high standard deviations reflect substantial heterogeneity in income among households, particularly in livestock-related activities (Table 1).

To facilitate interpretation, we distinguish between three types of economic indicators used throughout this study: (i) household level income (US$ year^{-1}), reflecting overall livelihood outcomes; (ii) per hectare measures (US$ ha^{-1} year^{-1}), capturing production intensity; and (iii) relative cost indicators (percent of income), describing the proportion of resources allocated to production. These metrics capture complementary dimensions of economic performance and are not directly comparable.

On the other hand, costs were divided into two categories: (i) production costs, including expenses related to seeds and labor; and (ii) marketing costs, covering transportation expenses for product sales. At the household level, total costs ranged between 8% and 19% of the total year income across the three study sites. At first glance, this relatively low cost-to-income ratio suggest favorable profitability. However, this interpretation is misleading when absolute income levels are considered. Annual agricultural incomes remain low in all communities and are insufficient to generate meaningful economic benefits for farming households. In this context, similar cost-to-income ratios can occur across systems with very different income levels and should therefore not be interpreted as indicators of economic efficiency.

When expressed in absolute terms, annual monetary expenditures ranged from

Figure 2. Distribution of Economic Activities and Income per Year in Taisha, Tuutinentsa, and Macuma, Morona Santiago, Ecuador
Other income comes from public employee salaries (e.g., teacher, assistant, secretary, driver, etc.). Livestock income comes from the sale of cows, pigs and poultry, and agricultural income comes from cash crops.



US$173 to US$467 ha^{-1} year^{-1}, indicating relatively low levels of capital investment. These values are well below those reported for more intensified smallholder systems in the Ecuadorian Coast and Highlands (approximately US$500–US$1,500 ha^{-1} year^{-1}), and considerably lower than commercial agricultural systems, where production costs can exceed US$1,500–US$3,000 ha^{-1} year^{-1} depending on the crop (FAO, 2018; Instituto Nacional de Estadística y Censos [INEC], 2017, n.d.). In this context, the low cost-to-income ratio observed in this study reflects limited input use rather than high capital efficiency.

This interpretation is further supported by the reliance on nonmonetized resources, including family labor, recycled planting material, and on-farm preparation of biofertilizers and biofungicides. In practice, planting material for cacao nacional, peanuts, and plantain is commonly reused from a previous harvest or sourced locally from farmers' own fields, while the few inputs applied (biofertilizers and biofungicides) are prepared using artisanal methods. As a result, the low recorded production costs reflect both restricted access to capital and production strategies that prioritize the use of locally available resources, which are characteristic of smallholder systems in the Ecuadorian Amazon.

Within the cost structure, transportation for crop sales emerges as one of the most significant monetary expenses, accounting for approximately 6%–20% (US$113 to US$230 per year) of annual total income, representing 57%–83% of total costs. While these percentages indicate transportation's relative importance, they should not be interpreted as evidence of affordability. In absolute terms, transportation can be a significant financial burden, especially in more remote communities such as Tuutinentsa, where access to markets is limited.

In addition to monetary costs, family labor constitutes a major noncash input across all agricultural activities. Although it does not involve direct financial transactions, it represents a substantial contribution to production and was included in the analysis to better reflect the full cost structure. These noncash costs account for approximately 5% to 20% of total agricultural costs, underscoring their relevance in household decision-making, particularly when family members consider migrating to urban areas or reducing their participation in farm activities.

We observed a similar pattern in livestock (cattle) systems, where monetary costs, such as vaccines and feed supplements, represent about 1%-7% of annual total costs of livestock production. In absolute terms, these expenditures are relatively low (US$12-US$220 per year) when compared to annual livestock income (US$1.416-US$2066 per year). Although these values reflect low levels of financial investment, they also point to limited profitability, as evidence by the low cost to income ratio (0.9%-11%). Rather than indicating efficiency or high returns, these rations primarily reflect minimal reliance on external inputs and services.

Overall, this cost structure is consistent with extensive production systems, in which both crop and livestock activities operate under conditions of limited access to capital, technical services, and formal markets. In this context, livestock often functions less as a profit-maximizing activity and more as a form of savings or asset accumulation, contributing to household resilience rather than short-term income generation.

Analysis of Commercial Crops

Cacao is the crop with the largest cultivated area (0.3–5.0 ha) compared to peanuts and plantain (Table 1), generating average income ranging from US$500 to US$700 ha^{-1} year^{-1} from pulp-grain mass (i.e., the amount of wet beans and pulp). Dried cacao in Taisha, Tuutinentsa, and Macuma (0.25, 0.26 and 0.30 t ha^{-1} year^{-1}, respectively) are lower than provincial and national reference values. However, these benchmarks should be interpreted cautiously, as chakra-based systems are not designed to optimize single-crop yields but to balance multiple outputs. Reported yield differences are associated with low levels of external inputs and management practices consistent with household labor availability and local agroecological knowledge, rather than with a lack of technical capacity.

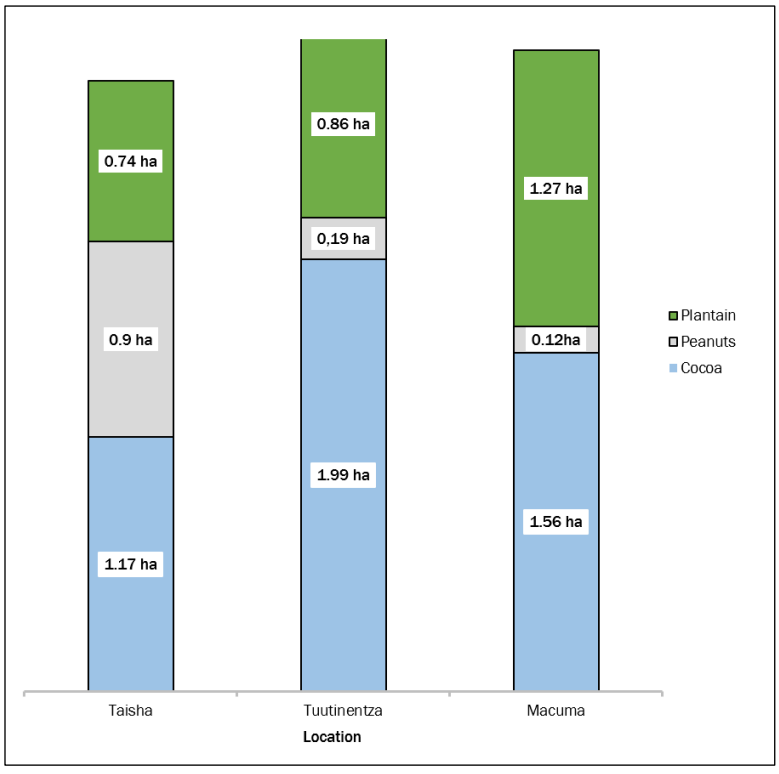
In the same context, peanut cultivation shows lower yields (907 kg ha^{-1} year^{-1}) than the national average (2.268 – 2.722 ha^{-1} year^{-1}). Additionally, we observed that farmers dedicate limited time to

the post-harvest process (i.e., removing peanut shells), a key step for improving quality and achieving a better market price. Although peanut cultivation can generate up to US$2,000 ha^{-1} year^{-1} under national average conditions, yields in the study area are substantially lower due to management constraints. As a result, peanut cultivation is generally maintained at a small scale, with approximately 95% of cultivated plots being less than 1 ha (Figure 3), reflecting farmers' risk management strategies rather than expected profitability. The small cultivated areas may be related to the cultural practice of integrating peanuts in chakra.

Plantain is an important crop that is primarily intended for household consumption, with only the surplus sold in local markets. The cultivated area is less than 1.5 ha (Figure 3). The harvested plantain is sold only in local markets, although with lower demand compared to cacao and peanuts. Only 33%–50% of farmers in the three communities sell part of their plantain harvest, while the remaining respondents use the crop for subsistence purposes. The average income from plantain is US$761, US$358 and US$219 ha^{-1} year^{-1} in Taisha, Tuutinentsa, and Macuma, respectively. These income levels correspond to yields of 3.69, 1.73, and 1.06 t ha^{-1} year^{-1}, which are approximately 2, 4, and 7 times lower than the national average plantain yield of 7.47 t ha^{-1} year^{-1} reported by the Instituto Nacional de Estadistica y Censos (INEC, n.d.). This comparison highlights the substantial productivity gap between the study area and national production conditions.

Livestock farming also contributes to household income, although its role varies across communities. The GAD provided significant support to cattle production through technical assistance to farmers, primarily in the form of genetic improvement programs using artificial insemination for dairy cattle. On average, each household sold approximately three head of cattle annually, generating annual income ranging from US$1,200 to US$2,011. These values fall within the national price range for adult cattle (US$376 to US$710 per animal), indicating that livestock prices in the study area are broadly consistent with national market conditions. Other animals, such as pigs, chickens, and ducks, are primarily raised for household consumption (86%), with only 3.5% sold at the farm or local markets, contributing marginally to household income.

Figure 3. The Average Area (ha) is Devoted to the Three Main Crops (Plantain, Peanuts, and Cacao) that Generate Income for the Household Economy of Small Farmers in Taisha, Tuutinentsa, and Macuma, in Morona Santiago, Ecuador



To complement these household-level estimates, we conducted an opportunity cost analysis for commercial activities to compare their cash-income potential per hectare under observed production conditions. This indicator reflects short-term monetary returns and does not capture nonmarket values that are central to chakra-based agroforestry and forest systems, such as household food provisioning, cultural continuity, or ecosystem services.

Opportunity cost estimates varied

across activities and communities. Peanuts showed higher short-term cash return per hectare ranging from US$1.961 to US$2.056 ha^{-1} $year^{-1}$, compared to cacao (US$327 and US$439 ha^{-1} $year^{-1}$) and plantain (168–714 ha^{-1} $year^{-1}$), reflecting shorter production cycles and lower establishment costs. Livestock exhibited lowest returns in Taisha and Tuutinentsa (US$55.9 and US$68.9 per year, respectively), while Macuma reported a higher income (US$485 per year), reflecting differences in herd size, commercialization patterns, and market integration values associated with greater herd sizes (Table 1).

It is important to note that these opportunity cost estimates are expressed on a per-hectare basis for specific activities and are not directly comparable to household-level income from livestock sales. In these systems, cattle are typically managed under extensive grazing systems, characterized by low stocking densities and a reliance on relative large grazing areas, including communal or shared land, meaning that income from livestock is more closely linked to herd size and sales dynamics than to individually managed land area.

Cacao occupies a larger cultivated area across communities and provides a more stable source of monetary income over time, complementing other livelihood activities rather than substituting for them. High standard deviations in opportunity cost values across cacao, peanuts, plantain, and livestock indicate substantial heterogeneity among households, driven by differences in production scale, market access, labor activity, and cost structures, which result in wide dispersion of opportunity costs.

Market prices strongly influence opportunity cost estimates; for example, shelled peanuts commanded the highest price (US$1.08 kg^{-1}) among products during the survey period. However, limited cultivated areas, labor-intensive post-harvest processing, and household labor constraints restrict expansion. These results illustrate trade-offs in diversified livelihood portfolios and should not be interpreted as recommendations for land-use conversion or agricultural intensification.

Opportunity cost metrics are useful for understanding income constraints, but they are insufficient to evaluate the overall performance of Indigenous agroforestry systems, which pursue multifunctional objectives beyond monetary returns. These indicators should therefore be interpreted as partial measures of short-term cash-income potential, rather than as indicators of system efficiency or productivity in a broader socioecological sense.

The average opportunity cost of cacao and peanuts is relatively similar across the three communities. In contrast, plantain production shows substantial variation among communities, with the largest difference observed between of Taisha and Macuma (approximately 4:1), and intermediate ratio when comparing Tuutinentsa and Macuma (approximately 2:1).

In these two communities, the opportunity cost for plantain differs from that of cacao due to differing economic priorities. For example, in Macuma, a greater reliance on off-farm employment reduces household labor availability for crop management, which influences both cultivated area and crop specific opportunity costs. Despite having a larger planted area than Taisha, its plantain yields are lower (3.69 t ha^{-1} yr^{-1} in Taisha versus 1.06 t ha^{-1} yr^{-1} in Macuma). Lastly, the opportunity cost of livestock production is notably higher in Macuma (US$485), which may be attributed to the number of cattle and stronger market integration, rather than differences in land productivity alone.

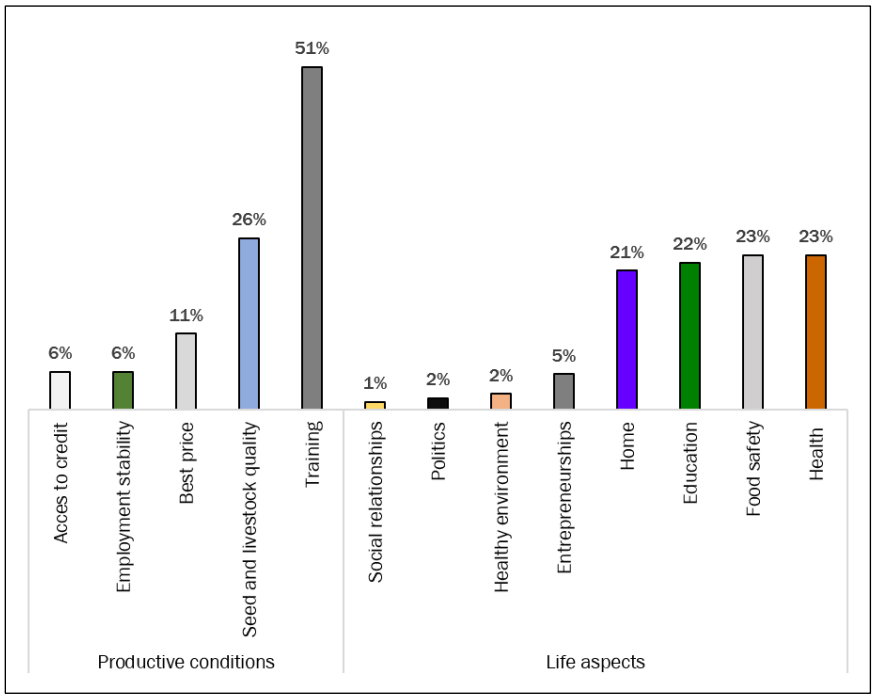
Perceptions of Well-being

We assessed the perceptions of farmers of well-being at the household level, encompassing environmental, economic, and social dimensions. From an environmental perspective, respondents consistently identified the forest as a highly valuable resource that supports agricultural activities, food security, and livelihoods. Farmers emphasized the importance of conserving the forest, while also recognizing its role in providing material for household use, particularly timber for home construction. Although we observed small-scale timber extraction , it was described primarily as a supplementary and opportunistic activity rather than a central livelihood strategy.

From a socio-economic standpoint, respondents reported that improving the performance of marketed activities should require better access to technical training, planting materials, livestock

quality, markets access, and credit. These responses reflect perceived constraints within current market and service infrastructures. Respondents identified access to credit as a need but did not specify a preference for subsidized or low-interest loans. In this study, well-being is understood as a multidimensional concept encompassing food security, health, education, housing, and livelihood stability, rather than income alone. From this perspective respondents associated quality of life primarily with consistent access to healthy and safe food, free medical care for their families, educational opportunities for children, and homeownership (Figure 4). These well-being priorities are closely linked to livelihood strategies, as 71.4% of the surveyed farmers mentioned that migration to larger cities is considered an alternative to provide their children with better educational opportunities, with the expectation that somemay later return to their communities and contribute to the continuity of family livehoods and traditions. In contrast, 14.3% of respondents attributed children's migration to declining agricultural well-being, including low crop yields, falling prices, and limited local employment opportunities.

Figure 4. Identified Access Needs to Improve Farmers' Productive Conditions and Essential Life Aspects in Taisha, Tuutinentsa, and Macuma, Morona Santiago, Ecuador



Discussion

Our study identified cacao, peanuts, and plantain as the primary commercial crops in the study area, complemented by other crops cultivated at smaller scales, which contribute to household diets and local exchange. These diversified livelihood strategies are consistent with previous research in the Amazon, highlighting their role in reducing dependence on single commodities and buffering households against market volatility (Rudel et al., 2002; Vasco et al., 2018).

The chakra is integral to the cultural identity of Indigenous nationalities. It serves as a means to cultivate food crops that meet the nutritional and medicinal needs of families, thereby ensuring food security (Perreault, 2005; Sirén, 2007; Torres et al., 2014). This small plot of land also serves as a space of informal social interaction, particularly among women, who combine agricultural tasks with childcare while engaging in conversation and mutual support during field activities, as indicated by Palacios (1999) and observed in this study.

A 10-year study conducted in the northern Amazon revealed that 69.4% of the farms sampled at the beginning of the study had been subdivided (Bilsborrow et al., 2004). The authors distinguished between two types of landowners: long-term owners who typically manage larger landholding (>30 ha) with limited subdivision and maintain a higher proportion of the forest or grassland cover, and short-term owners, who manage smaller plots resulting from subdivision through inheritance or land sales. Our findings align more closely with the characteristics of long-term landowners.

Agricultural soils in the Amazon are widely recognized as vulnerable to ero-

sion, nutrient loss, and declining fertility under intensified use (Vasco et al., 2013). In this context, the use of crop rotation, diversified planting, and organic matter management reflects adaptive responses to biophysical constraints rather than a lack of technical knowledge (Altieri, 2004; Corsi et al., 2012; Ellis, 2008). Differences in crop performance, including plantain and cacao yields, are shaped by interactions among soil conditions, climate variability, and disease pressure.

Our findings suggest that productivity outcomes are shaped less by isolated technical interventions than by broader structural and ecological constraints. In the case of cacao, susceptibility to diseases such as frosty pod rot (*Moniliophthora roreri*) and witches' broom (*Moniliophthora perniciosa*) interacts with locally adapted management practices and household labor constraints, influencing yields over time (Ceccarelli et al., 2024). Similar dynamics apply to practices such as grafting or crown replacement using plant material that is high-yielding and disease-resistant..

Monetary incomes from agriculture and livestock in the study communities are low relative to national averages, consistent with broader regional patterns (Córdova et al., 2019; Vasco et al., 2013). However, well-being in Indigenous contexts extends beyond cash income to include food provisioning, forest access, social networks, and cultural continuity (Barbieri et al., 2005). Low monetary returns are largely shaped by structural market constraints such as low farm-gate prices, weak infrastructure, and limited value chain integration (Nieto & Caicedo, 2012).

In this context, cost-to-income ratios must be interpreted with caution. Although these ratios appear relatively low, they primarily reflect the limited use of external inputs rather than high economic efficiency. In absolute terms, household incomes remain modest across the study sites, constraining their capacity to generate meaningful monetary returns.

Annual agricultural incomes of US$2,306, US$1,834, and US$1,221 remain low in absolute terms and limit the capacity of these systems to support improved economic outcomes. While comparisons across regions should be interpreted cautiously due to differences in production systems and market integration, smallholder cacao producers in Ecuador's coastal region have been reported to achieve higher average annual incomes (approximately US$5,000), even under low-input conditions. This contrast suggests that low cost-to-income ratios do not necessarily reflect economic viability, but rather the low-input nature of these systems, where limited investment is associated with constrained income generation.

Transportation costs emerge as a key constraint affecting the economic performance of agricultural systems in the study area. Although these costs represent a relatively small proportion of annual net income (approximately 6-20%), they should not be interpreted as a share of total production costs. Rather, they reflect the structural limitations associated with market access in remote Amazonian communities. Because both total costs and individual cost components are expressed relative to income, these metrics are not directly comparable. In absolute terms, transportation constitutes a significant financial burden, particularly in isolated areas such as Tuutinentsa, where limited infrastructure increases transaction costs and reduces market integration.

In this context, it is helpful to distinguish between household-level income and per-hectare economic measures. While livestock contributes to overall household income through animal sales, opportunity cost estimates are calculated per hectare for specific activities and are therefore not directly comparable. In these extensive systems, livestock income is shaped more by herd size, market access, and sales decisions than by the amount of individually managed land.

This study also highlights how low income and opportunity costs across communities reflect not only crop performance but also factors such as market proximity, herd size, off-farm employment, and culturally embedded land-use priorities (Kolinjivadi et al., 2015). Including family labor costs underscores the limits of monetary indicators in evaluating multifunctional Indigenous agroforestry systems (Mora-Delgado et al., 2007). Although this labor does not involve direct monetary transactions, it represents a substantial contribution to production processes and was valued using standardized wage proxies. This highlights the extent to

which household labor substitutes for external inputs in low-input production systems. Rather than signaling inefficiency, these metrics reveal trade-offs within diversified livelihood strategies that prioritize resilience, food sovereignty, and long-term socioecological stability over short-term income maximization.

These findings highlight the importance of recognizing the multifunctional nature of Indigenous agroforestry systems and the limitations of one-size-fits-all frameworks focused solely on yield or income maximization. Consequently, training programs should prioritize soil conservation practices, including minimal tillage, crop rotation, and organic matter application, alongside the diversification of agroecological crops (Altieri, 2004; Corsi et al., 2012; Ellis, 2008).

Moreover, enhancing crop management practices is a key pathway to preventing production issues throughout the crop cycle In the case of plantain, the lack of essential agricultural practices such as fertilization, weed control, and disease management is a primary factor explaining why yields in the study communities are 2 to 4 times lower than the national average plantain yield of 7.47 t ha^{-1} $year^{-1}$, as reported by the National Institute of Statistics and Census (INEC, 2017). For cacao, reliance on seed-derived planting material can limit yield potential due to genetic heterogeneity, a pattern widely reported across cacao producing regions. This is a common characteristic in all cacao-producing countries.

As previously discussed, the economic activities of rural families in the EAR are primarily based on agriculture and livestock farming. However, these activities contribute to high levels of rural poverty, attributed to the low market price of primary products such as plantain, cassava, and others, which are sold at the local market level in the first stage of the supply chain (Nieto & Caicedo, 2012). At the same time, the importance of food security encourages Amazonian farmers to increasingly focus on maintaining forested areas, which provide direct economic and subsistence benefit through sustainable timber use and nontimber forest products such as wild fruits, fibers, and seeds (Barbieri et al., 2005). These forest resources complement diversifying farming systems that combine annual, short-cycle, and perennial crops with small-scale livestock production.

Within these systems, livestock also functions as a form of savings and financial buffer, rather than as an intensively managed production activity. This helps explain why livestock can contribute to household income despite low levels of monetary investment.

Our findings showed that a high percentage of farmers in the communities studied earn an average monthly agricultural income of approximately US$300 (Instituto Nacional de Estadística y Censos, 2021). This income pattern among small-scale farmers is consistent with previous studies conducted in other provinces of the EAR (Córdova et al., 2019; Vasco et al., 2013, 2015). Despite the long-standing policy objective of poverty reduction, investment in the agricultural sector remains limited, and the effectiveness of these investments in improving rural livelihoods remains uneven.

Limited investment in the productive sector continues to constrain agricultural development and highlights the challenges faced by family farming in the Amazon (Inter-American Institute for Cooperation on Agriculture, 2018). The use of recycled seeds, defined here as farmer-saved planting material selected from a previous harvest (e.g., beans and pods) and replanted without genetic or quality certification, together with limited working capital for purchasing organic inputs and the absence of essential equipment for pruning and weed control, contributes to heterogeneous plant stands, reduced vigor, and increased susceptibility to pest and diseases. In addition, institutional barriers to credit—particularly the absence of individual land titles—exclude many farmers from formal financial systems, limiting their capacity to invest in productivity-enhancing practices (Bilsborrow et al., 2004).

These constraints are reinforced by poor infrastructure, limited market access, and restricted opportunities for value addition. Under these conditions, off-farm employment, particularly among adolescents and young adults, is perceived as a strategy to improve household income and finance education (Barbieri et al., 2005; Bilsborrow et al., 2004; Sellers et al., 2017). Agricultural income and activities in the EAR vary based on specific local conditions. Torres et al. (2018) reported an average

annual agricultural income of US$2,199 in the northern Amazon, whereas in the present study, the average annual income was US$1,746 . Importantly, the inclusion of family labor costs in the present analysis provides a more accurate representation of net income and opportunity costs across production systems (Mora-Delgado et al., 2007).

Conclusion

As discussed in this study, rural poverty in the Ecuadorian Amazon is shaped by a combination of structural, economic, and institutional factors that condition agricultural and livelihood outcomes. The results indicate that these conditions do not reflect a failure of Indigenous farming systems; instead the socioeconomic conditions documented in this study highlight the constraints faced by Shuar households in accessing markets, public services, infrastructure, and supportive policy frameworks. By examining the contribution of agricultural and livestock activities to household income, our findings align with previous studies showing that rural livelihoods in the Amazon are embedded in diversified, low-capital strategies that balance food security, risk management, and cultural continuity.

Our study also highlights a gap between the design of public policies and their implementation on the ground, particularly the difficulty of aligning top-down development strategies with locally embedded practices and priorities. This is reflected in the limited documented impact of existing programs in the study communities discussed above. The needs identified by Shuar farmers (e.g., strengthening traditional production systems, access to credit adapted to their economic realities, and securing planting materials appropriate to local agroecological conditions) are not always reflected in existing programs. This misalignment underscores the importance of policy frameworks that are responsive to Indigenous socioecological realities.

Consistent with the discussion, the results emphasize the limitations of conventional economic indicators, such as opportunity cost, when the applied in isolation. While these metrics are useful for comparing short-term cash income, they do not capture the broader set of values embedded in Indigenous agroforestry systems, including food provisioning, ecosystem services, and cultural practices.

Based on these findings, our results highlight the importance of development approaches that recognize the multifunctional nature of chakra-based farming systems, support culturally appropriate value chains, and value local knowledge and governance structures through bottom-up strategies. Such approaches are better suited to strengthening livelihoods while maintaining ecological integrity and cultural continuity in Indigenous Amazonian territories.

Finally, we suggest the use of monitoring and evaluation indicators as complementary mechanisms to assess the effectiveness of existing national and regional programs, such as payment for environmental services schemes and territorial development plans in reaching Indigenous communities. While such initiatives (e.g., "Socio Bosque" and "2024–2025 Development Plan") formally aim to enhance agricultural productivity, promote environmental sustainability, and reduce rural poverty, their outcomes at the local level remain insufficiently documented in Amazonian communities.

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Social, cultural, political, and human capital perceptions by young food system professionals

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Abstract

The Community Capitals (CCs) model has been applied to numerous food systems and community development efforts. This paper utilizes the CCs framework to understand how it informs the operations of food system organizations in Vermont. We focus on four capitals without clear units of measurement: social, human, cultural, and political. These capitals have been highlighted in previous research as being less commonly and easily identified by food systems stakeholders. We conducted interviews with 10 early-career professionals across the state. The purpose of the inquiry was to measure how our respondents understand these capitals and how they underpin the respondents' work. Questions focused on how respondents and their organizations define and operationalize these four

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capitals and their roles in food resilience. Respondents emphasized the value of investing in collaborative relationships, recognizing experiential knowledge, supporting advocacy efforts, and actively addressing equity concerns. This study contributes to a broader understanding of how CCs support resilient food systems. Future research could further explore how to address diversity gaps in food system networks and promote collaboration.

Keywords
food resilience, community capitals, stakeholders, Vermont

Introduction

Food systems play a critical role in supporting human well-being, livelihoods, and essential life-supporting services (Vroegindewey & Hodbod, 2018). However, food systems are vulnerable to political, natural, and economic disruptions that can have far-reaching effects worldwide (Toth et al., 2016). Building resilience in food systems therefore has become increasingly important, to enable communities to withstand shocks, adapt to changing conditions, and transform when needed.

The Community Capitals (CCs) framework, introduced by Flora et al. (2003) and applied by Emery and Flora (2006), identifies seven forms of capital: natural, cultural, human, social, political, financial, and built (Daniel et al., 2022). Four of these—social, cultural, human, and political capital—may be less tangible and more difficult to measure but play crucial roles in community development and resilience (Mueller et al., 2020). Social capital refers to relationships and networks; cultural capital encompasses shared values and practices; human capital involves skills and knowledge; and political capital relates to power and engagement in decision-making. Previous research in Vermont found that stakeholders were better able to identify CC assets that have a clear unit of measurement, for example, financial (dollars), built (square feet), natural (acres), and clear means of investment (Conner et al., 2023). Our work complements previous findings and extends their insights.

Vermont provides an interesting case study for examining food system resilience through the lens of CCs. The state is nationally recognized for its vibrant local food movement and innovative food policies (Olson, 2019). Initiatives like Farm to Plate have significantly promoted local food consumption and sustainable farming practices (Farm to Plate, n.d.). However, Vermont faces challenges including rising food insecurity, farm viability pressures, demographic shifts, and climate change impacts (Rortvedt, n.d.). While the CCs framework has been applied to understand food systems in other regions (Stone et al., 2024), there is a lack of research on how it can contribute specifically to building Vermont's food system resilience.

This study aims to address this gap by assessing how these four capitals (social, cultural, human, and political) can contribute to building resilience in Vermont's food system, by examining the perceptions of early-career professionals in local food systems organizations. The findings illuminate how different forms of CC operate in practice to support or hinder food system resilience. Our research contributes to a deeper understanding of the role of CCs in food system resilience and offers practical insights for researchers, policymakers, and practitioners working to strengthen local food systems.

Literature Review

This literature review examines the relationship between community capitals and food system resilience, with particular attention to social, cultural, human, and political capital. We first review the concept of food system resilience and the Community Capitals framework, followed by literature on each of the four capitals and how they have been conceptualized and measured. We then identify gaps in the existing literature that inform the focus of this study.

Community Capitals and Food Resilience

Resilience is seen both as a process and an outcome (Manyena, 2006). Herrmann and colleagues (2011) referred to resilience as "positive adaptation despite experiencing adversity" (p. 259), and as the ability of a system to sustain itself through change by adaptation and occasional transformation (Magis, 2010). Accordingly, when a system can adapt to changes, it is said to be persistent or resili-

ent (Egamberdiev, 2024).

In the event of a disaster, resilience measures a community's capability of restoring the original predisaster state as well as coping with emerging postdisaster situations and changes (Kais & Islam, 2016). Resilience efforts often emphasize longer-term preventative measures rather than short-term beneficial responses, such as enacting policy interventions and strategies that promote well-being and successful adaptation (Egamberdiev, 2024).

Food System Resilience

Understanding food system resilience is crucial because food, nutritional outcomes, livelihoods, and many other essential life-supporting services are derived from food systems (Vroegindewey & Hodbod, 2018). In Vermont, interest in local food systems is growing, and efforts to establish adaptive governance to support action are increasing (Skog et al., 2018). As a state that is "home to many local food initiatives" (Whitehouse et al., 2023, p. 203), Vermont boasts the highest national spending per capita on direct-to-consumer sales (Olson, 2019). The Farm to Plate initiative, launched in 2009, has been a significant driver of Vermont's food system development. The initiative aims to increase economic development and jobs in the farm and food sectors while improving access to healthy local food for all Vermonters, which has greatly contributed to promoting local food consumption and supporting sustainable farming practices (Farm to Plate, n.d.). Vermont's food system also has a positive employment impact on other sectors of the economy, with a 2.8% increase in employment in food systems in the year 2023 (Vermont Sustainable Jobs Fund, 2024).

Community Capitals Model

The more easily measured CCs—built, financial, and natural capitals—refer, respectively, to a community's physical infrastructure (e.g., homes, factories, transportation); its material property, wealth, and other financial sources that can be invested in the community; and the availability and sustainable use of natural resources for human consumption (Flora, 2018). Our study focuses on the remaining CCs, which refer to less tangible assets that are mainly found in the social structure of communities, and are typically expressed through interpersonal connections, cultural standards, and informal networks (Mueller et al., 2020). Social capital is the size and density of social networks within a community. Cultural capital is the community's worldview, values, traditions, and norms. Human capital includes a person's natural and acquired personal qualities, such as job experience, education, knowledge, and health, that support one's capacity to make a living and build community (Nosratabadi et al., 2020). Finally, political capital is community members' ability to access resources, power, and power agents (Kais & Islam, 2016). Importantly, these four capitals are often overlooked by stakeholders engaged in strengthening food system resilience (Conner et al., 2023).

Social Capital

Social capital represents the relationships among people in society (Egamberdiev, 2024; Whitham, 2012). Researchers have argued that social capital is important for building food system resilience by promoting connections both within and outside the community (Aldrich, 2017; Glowacki-Dudka et al., 2013). Social capital can be seen as the benefits derived from the interaction between different networks and groups, such as resources created in human networks with common norms that facilitate social transactions and achieving societal goals for members, and community belonging (Carpiano & Hystad, 2011). Another study (Cramm et al., 2013) defines social capital and social cohesion as resources accessible to individuals through their affiliation with a group or community, such as shared norms of give-and-take, involvement in community activities, confidence in others, and the advantages of being part of a group.

Social capital serves as a potential element for enhancing resilience (Aldrich & Meyer, 2015). Social capital can contribute to food security through the synergy that is created from the interrelationship among community members at the various stages of the food supply chain from production to consumption (Nosratabadi et al., 2020). In building resilience, examining social capital provides insight into the complexity and dynamics a community faces at times of disruption (Roque et al., 2020). According to Aldrich & Meyer (2015),

strengthening social infrastructure such as social capital can be an approach to predisaster mitigation, which affects the recovery process and contributes to community resilience. Social capital can increase access to the information, resources, capital, and expertise needed to promote development (Roque et al., 2020), and can function as a gap-filler when governments and markets fall short (Aldrich, 2015).

The development of resilience capacity is closely tied to the empowerment of individuals through collective actions and social dynamics; the relationship between social capital and resilience is not one-sided, but instead flows both ways (Egamberdiev, 2024; Fischer & McKee, 2017; Hayward, 2013). For example, *bonding* social capital strengthens local ties, while *bridging* social capital extends these connections to external networks, thereby enhancing resource access and collaboration (Furness et al., 2022; Spring et al., 2018). In Vermont, initiatives that promote community supported agriculture have demonstrated how social capital can lead to transformative changes in food systems, which enable communities to adapt to challenges and leverage collective resources (Furness et al., 2022).

Measuring Social Capital. Scholars emphasize the need for social capital to create agency and inspire community action and civic engagement (Beaulieu, 2014; Butler Flora & Bregendahl, 2012; Fey et al., 2006). Previous studies have measured social capital as relationships and networks of trust, reciprocity, equity, inclusions and belonging, which are measured by number, strength, diversity, and longevity of links between different types of organizations (Beaulieu, 2014; Butler Flora & Bregendahl, 2012; Dale & Newman, 2010; Emery & Flora, 2006; Fey et al., 2006; Flora, 1998).

Cultural Capital

Cultural capital is viewed as a community's beliefs, customs, attitudes, values, and behavior (Hale et al., 2023). It can be referred to as creative industries and amenities; a distinct social group; knowledge, values, attitudes, norms, and beliefs; and place-based characteristics. Ohashi and colleagues (2017) delved into the concept of cultural capital in the context of public health; they identified *autogenic ability*, the capacity to adapt and self-manage in response to daily challenges, as a key attribute of cultural capital. Applied to food systems, autogenic ability reflects a community's capacity to rely on internal strengths, local knowledge, and shared cultural practices to navigate disruptions. Communities with strong cultural capital often rely on themselves and draw from local resources, which helps them enhance their capacity to respond to disruptions in global food systems. Vermont's food system has been promoted by local and national media outlets as having a vibrant culture (Burros, 2008; Charles, 2011; Olson, 2019).

The notion of cultural capital was originally developed by Pierre Bourdieu (Ohashi et al., 2017), who asserted that it "can exist in three forms" (Bourdieu, 1986, p. 243). These refer to: (1) the "embodied state ... of long-lasting dispositions of the mind and body"; (2) "the objectified state ... of cultural goods (pictures, books, dictionaries, instruments, machines, etc.)" that people produce; and (3) "the institutionalized state" of markers such as "educational qualifications" (Bourdieu, 1986, p.243). Thus, cultural capital can be observed in individuals, materials, and broader systems and organizations that may confer, enact, and enable cultural capital.

Goulding (2008) views cultural capital as a set of cultural competencies that is needed for effective understanding and participation in cultural activities that are recognized and rewarded by the education system, thereby giving access to social and economic advancement, and reproducing existing class divisions. Closing these diversity gaps requires intentional strategies that go beyond initial inclusion efforts (Roberson, 2019). In Vermont, local cultural values inform food production and consumption practices, which contribute to a more resilient food system (Olson, 2019). By integrating cultural elements with new knowledge and practices, communities can create food systems that are not only sustainable but also reflective of their unique identities (Spring et al., 2023). Further, integrating local knowledge and practices can enhance food security and promote ecological sustainability (Sidiq et al., 2022).

Measuring Cultural Capital. Previous research has measured cultural capital via shared

values and history, volunteerism, language, symbols, and beliefs, including material expressions such as art, clothing, and books, and efforts to preserve or sustain cultural practices like festivals, museums, and other cultural events (Beaulieu, 2014; Butler Flora & Bregendahl, 2012; Fey et al., 2006; Lundgren & Nilsson, 2023).

Human Capital

Human capital is the set of knowledge, skills, and experience that workers have in the economy (Gruzina et al., 2021; Subramony et al., 2018). Human capital influences economic growth and can contribute to the development of an economy by increasing the knowledge and skills of its people, conditional upon the presence of supportive economic and institutional environments (Ali et al., 2018). Human capital is increasingly recognized as a pivotal factor in sustainable economic development (Astachova, 2023). Developing human capital increases workers' productivity while at the same time increasing capacity in other areas of life, such as health, education, and employment (Li et al., 2017).

High levels of human capital can enable economies to innovate and diversify, mitigating the risks of overreliance on specific sectors that may lead to cyclical downturns (Astachova, 2023; Goloshchapova et al., 2023). Resilient food systems require human capital for building more effective knowledge systems (Cash et al., 2003; Danish et al., 2019; Gruzina et al., 2021).

Measuring Human Capital. Previous research has measured human capital as knowledge and skill development and management capacity, youth retention in education, and investments in health, education, and institutional frameworks. At the more macro level, it can be measured by health outcomes, productivity, and crime and employment rates (Butler Flora & Bregendahl, 2012; Deller et al., 2001; Fey et al., 2006).

Political Capital

Political capital relates to power, representation and engagement, resource allocation, and organization (Panzarella et al., 2023). Political skill is essential for effective organizational operations like securing resources and exerting influence to achieve favorable outcomes (Mintzberg, 1985; Perrewé et al., 2000; W. Wang et al., 2024b). Effective leaders continuously invest political capital in ways that yield the greatest return (Kjaer, 2013). For example, according to Liu and colleagues (2013), firms with executives who have political connections have a higher chance of getting approval and market premiums for an initial public offering.

Political connections and support are essential in the success and sustainability of Vermont's food systems. The Vermont Working Lands Enterprise Fund, for example, has distributed millions of dollars in grant funding to food and agriculture projects, a process that often benefits from political advocacy and alignment with state-level priorities (Vermont Agency of Agriculture Food and Markets, n.d.). The state's commitment to promoting local agriculture through policies such as the Farm to Plate Initiative exemplifies how political capital can enhance food system resilience (Conner et al., 2023).

Measuring Political Capital. Previous research has measured political capital as a community's ability to influence its policies (via elected officials and other decision-makers) and access to public resources. Measures include numbers of town halls, preponderance of young and women political candidates, communitywide levels of government expenditures, and degree of competitive elections (Beaulieu, 2014; Butler Flora & Bregendahl, 2012; Deller et al., 2001; Emery & Flora, 2006).

Research Gap

The CCs framework has been applied to understand how social, cultural, and human capitals are related to food access and adaptability in U.S. Midwest communities (Crowe & Smith, 2012; Stone et al., 2024). Midwest communities with strong cultural values and social networks were more likely to offer a greater variety of food sources to residents (Crowe & Smith, 2012). During an acute crisis—such as the COVID-19 pandemic—stakeholders regarded human capital as a strong asset despite weaknesses in other community capitals (Stone et al., 2024). There is less research on how CCs contribute to strengthening Vermont's food system. Further, many past studies utilize secondary data

(Deller et al., 2001; Fey et al., 2006) or primary data collected as part of a specific initiative (Butler Flora & Bregendahl, 2012; Emery & Flora, 2006; Lundgren & Nilsson, 2023). This study uses primary data to assess how young professionals in statewide food system organizations understand and operationalize social, cultural, human, and political capital. We focused on young professionals due to Vermont's aging population and its acute need to attract and retain young professionals (Flanders, 2024). The overarching goal of the study is to measure how food systems professionals conceive of and identify these capitals in their organizations, as well as how they describe the impact of the various capitals on their work.

Method

This study used a qualitative research design to examine how food system professionals understand and operationalize social, cultural, human, and political capital in Vermont's food system. The following sections describe the study sample and recruitment process, interview protocol, coding and analysis process, researcher positionality, and steps taken to maintain methodological rigor.

Study Sample and Recruitment

To understand social, cultural, human, and political capital in Vermont's food system, we interviewed key stakeholders ($N = 10$) across different organizations. Interviews provide rich, detailed data, enabling participants to express their perspective in their own words, delving into the why, and how, behind their actions and beliefs (Stuckey, 2013). We conducted interviews in February 2024 over Microsoft Teams; each interview lasted 30–60 minutes. Interview transcripts were automatically generated using Teams and were validated manually using Microsoft Word by the lead author to correct transcription errors. The University of Vermont (UVM) Institutional Review Board (IRB) (STUDY0001698) approved all protocols (recruitment materials, consent information sheet, and interview guide) ' before participant recruitment began.

We recruited participants using a purposive, convenience sampling strategy. A member of the research team who is a faculty member at UVM provided a list of possible interviewees. Most of the interviewees were known to the research team member from prior research interactions, including being former graduate or undergraduate students and/or having collaborated on research projects. Many of the interviewees attended and were introduced to the lead author at the 2023 Farm to Plate annual gathering, a key statewide food systems stakeholder meeting and one in which the CCs model had been previously explored (Conner et al., 2023). The participants' familiarity with the research team and subject matter resulted in ease of recruiting and interviewing; their familiarity does, however, create limitations, which will be discussed below.

The participants are mainly early-career professionals and hold a range of roles in their respective organizations. From our literature review, we found that many researchers gather information from senior leaders of organizations, but we decided to recruit early-career professionals because Vermont's aging population makes their perspectives particularly important and because they are directly involved in the day-to-day operations of their organizations and can provide valuable insights into how organizational policies and norms are implemented in practice. We suspected that, in interviews, senior leaders may be more likely to state the party line or to give answers that make the organization look good, and we were concerned that, like farmers, they may be experiencing survey fatigue. Therefore, we focused on the experiences of those whose views are less commonly represented in existing scholarship and who could provide fresh perspectives. The participants include a food hub account manager, a program manager, a director of a food hub, a director of strategic impact, a food system professional, a program coordinator, a program manager, and an office manager and events coordinator (Table 1). During the recruitment process, we first sent an email to potential participants to seek their consent (via IRB-approved email recruitment and information sheet) and interest in being interviewed and to share their availability for a meeting to be scheduled. All participants responded positively. See Table 1 for a summary description of each participant and their corresponding pseudonyms.

Data collection ceased after the tenth interview. We used the stopping rule of saturation, the point where data are adequate and appropriate for analytical depth, support of conclusions and minimizing risk of incomplete or biased findings (Ahmed, 2025; Duran et al., 2006; Jennings & Yeager, 2025). By the final interview, no new data emerged that provided novel insights, codes, or themes (Ahmed, 2025; Tong et al., 2007).

Interview Protocol

We designed semi-structured interview questions to focus on social, cultural, human, and political capital. The initial set of questions aimed to create a baseline to understand the participant's job role, occupation, and responsibilities. For *social capital,* the interview questions asked about the trust, relationships, and networks that promote collaboration in the community, with questions like, "how would you describe the social cohesion and trust you experience with other food systems organizations?" and "what other food system organizations do you work with?" Questions about *cultural capital* delved into the values, norms, and traditions that define the organization. We designed the questions to understand the extent to which these organizations' mission and vision statements reflect their cultural identity. The *human capital* questions focused on the skills and knowledge that individuals bring to and acquire within the organization. Questions such as "What sorts of training or professional development have you engaged in since beginning work here?" aimed to evaluate how organizations are committed to employee growth. *Political capital* questions explored the organization's role in policy advocacy, its internal decision-making processes, and the extent to which employees are encouraged to participate in policy activities. The semi-structured format allowed the interviewer to ensure that key topics were covered while allowing for probes to gain greater insight (Ahmed, 2025). The interview guide is available from the authors on request.

Coding and Analysis Process

Coding is a critical component of qualitative research that involves breaking down data into distinct parts, closely examining them, and comparing them for similarities and differences (Cope, 2021; Saldaña, 2015). We used NVivo, a qualitative data analysis software, throughout the coding process. The responses pertaining to definitions of the four CCs were coded in an *a priori* deductive manner, based on research and interview questions (Bingham, 2023). Subsequently, the data were coded inductively for emergent and cross-cutting themes, carried out in three primary stages: **initial** coding (reviewing the transcripts to understand the data), a second coding round where **open codes** were applied to all sections of the interview, excluding the introductory and closing remarks, and a third round of coding, the **focused** coding stage where the codes were grouped into broader thematic categories (Bingham, 2023; Cope & Kurtz, 2023). This approach allows researchers to remain closely grounded in participants' words and perspectives, ensuring the analysis reflects the participants' realities (Saldaña, 2015).

Based on the three-stage approach, descriptive codes were initially generated based on the explicit content of responses. These codes were provisional and remained open to modification as the analysis proceeded. In the focused coding stage, the initial codes were evaluated and grouped into broader thematic categories, directly addressing the concepts of social, cultural, human, and political capital outlined in the research questions. Saldaña (2015) defines focused coding as the process of integrating and synthesizing significant and frequent codes to develop higher order themes and analytical codes. At this stage, the data are grouped into meaningful patterns, as relationships and connections between themes are identified. The themes were divided into subcodes to provide a detailed understanding for analysis. Throughout the coding process, analytical notes were written to capture reflections, questions, and emerging ideas as recommended by qualitative scholars (Cope, 2021; Cope & Kurtz, 2023; Saldaña, 2015).

A single coder (the lead author) analyzed the data , and was guided by extensive mentoring sessions (as recommended by Jennings and Yeager, 2025) by the fourth author, a well-published and recognized expert and instructor in qualitative methodology (e.g., Cope & Kurtz, 2023; Hay & Cope, 2021). The lead and fourth authors met

twice a month from August 2025–March 2026 to refine the codes. Specifically, the lead author shared proposed codes for each pertinent potion of interview transcript and in an iterative process until agreement was reached.

Table 1. Summary Description of Interview Participants

Pseudonym	Experience	Organization	Role
Rose	2 ½ years	Food hub	Account manager
Grace	4 years	State agency	Programs and outreach coordinator
Judith	6 years	Nonprofit	Operations manager
Bee	10 years	Nonprofit/Farmer	Director of strategic impact
Rita	4 years	Nonprofit	Director of development
Tenzin	2 years	Nonprofit	Programs and outreach coordinator
Omar	4 years	Nonprofit	Program coordinator
Matt	6 years	Nonprofit	Program associate
Mary	3 years	State agency	Project manager
Josh	3 years	Nonprofit	Office manager

Positionality Statement

As a Black international female graduate student, I (the lead author) acknowledge that my identity may have influenced the responses during the interviews with employees from Vermont food system organizations in different ways. My race and gender could influence how participants responded, particularly to questions about diversity. To investigate this potential influencing factor, I reviewed each organization's website in November 2024 for information on its values and stance on issues of diversity. This review showed that some of these organizations launched equity initiatives in 2020, while others also created an internal equity task force and issued public statements on racial justice. These factors may have made participants more favorable to my study, and this is taken into consideration.

Summary of Steps to Maintain Methodological Rigor

We took the following steps to ensure and demonstrate the methodological rigor of our qualitative study:

- Building on previous topical and methodological literature and highlighting the research gap and information needed to guide new inquiry (Duran et al., 2006)
- Descriptions of sampling, recruitment, interview instrument, and analytic processes (Tong et al., 2007)
- Use of memoing and analytical software (Tong et al., 2007; Ahmed, 2025)
- Extensive mentoring of student by experienced qualitative researcher (Jennings & Yeager, 2025)
- Positionality statement of lead author to reveal how researcher background influences interpretation and to enhance reflexivity (Tong et al., 2007)
- Discussion of limitations of research (Duran et al., 2006)
- Triangulation of results with other data sources (Ahmed, 2025; Duran et al., 2006; Tong et al., 2007)

Results

Table 1 summarizes the experiences, roles, and organizations of the sample.

Respondents' Descriptions of Social, Cultural, Human, and Political Capitals

Social capital is largely influenced by the state's small geographic size and the connected nature of its nonprofit and food-hub communities. Participants described how frequent interactions help build trust, foster mutual understanding, and encourage collaboration across organizations. One participant shared,

> I think the environment in the food systems world is really collaborative and that folks are friendly and have worked with each other in lots of capacities and have this built-in trust that allows work to move a lot quicker than if that wasn't established. (Grace)

These regular connections contribute to a sense of familiarity that supports effective communication and collective problem-solving. One participant described the social connection as positive, with a lot of collaboration between the Vermont nonprofits and the food hubs. Judith shared, "Honestly, it's been really positive, especially working with other food hubs and I mean, there's a lot of collaboration between the Vermont nonprofits and the food hubs in general."

The cultural capital embedded in these food systems reflects a blend of long-standing values and evolving, mission-driven practices. Participants described the cultural capital in the organization as a fast-paced, hardworking internal culture that is rooted in its mission and shared commitment to supporting the food system and its partners.

> I think that we're lucky to be a mission driven organization and it's always focused on supporting our food system, supporting our partners and our farmers. I think internally we all work hard and at a fast pace and that happens in a lot of businesses, and you know in nonprofits especially. (Matt)

Another participant described the cultural capital in the organization as connected to it being a woman-led organization and composed of young staff, which they saw as fostering a sense of innovation and transformative energy.

Human capital in these food system organizations is described as the knowledge, skills, and lived experiences that staff bring to their work. One participant shared:

> I had a passion for local healthy food and promoting that in communities and had some experience working with food pantries and food access organizations and organizing getting folks organized. What I brought to this work was a passion for local food and a desire to promote the local food scene in Vermont. I've really learned a lot and really, I gained a lot of skills in the past 2½ years working in this job. (Rose)

The respondents placed great value on experiential knowledge as a critical part of human capital. They described how their experiences across farming, food service, institutional roles, nonprofit leadership, and policy engagement have equipped them with the skills, insights, and confidence to navigate complex challenges in the food system. They described their experiences not only as a source of technical skill but also as a foundation for leadership and systemic understanding. One participant shared, "I have a lot of experience in the food system, from working in restaurants and grocery stores to being a farmer myself and knowing how difficult it is to grow and source food" (Matt). This experience is perceived as critical in navigating food system challenges, as it equips individuals with a multidimensional perspective and the adaptability needed to respond effectively to disruptions.

Experience was tied to people's personal involvement that contributed to a deeper understanding of how their organization works, its history, structure, and internal processes. This knowledge developed through many years of working in the food system sector. As a result, their experience helped keep their organizations steady and consistent and allowed them to guide or mentor others effectively. One participant shared, "I came into this role with a background in nonprofit fundraising, administration, and communications, and had completed a nonprofit management course. These experiences prepared me to manage finances, lead teams, and support board development" (Rita).

Participants also described how professional experience supported the acquisition of leadership and organizational skills. One person shared, "I have learned a lot about food distribution, food safety, and recognizing product quality. I also didn't know anything about fundraising or facilitating meetings before, but I gained those skills over time" (Tenzin). Participants highlighted the importance of experience in strategic roles that demanded communication with policymakers, funders, and organizational stakeholders. For example, "I've had opportunities to navigate different funders and manage the full lifecycle of grant projects. I've also grown in my ability to inform policy and engage legislators on issues our clients face" (Grace). Gaining knowledge through a range of professional roles enhances not only practical skills

but also strategic understanding and the ability to respond to challenges. In this way, experience reinforces both personal and organizational strength, supporting the flexibility and enduring viability of Vermont's food system.

Political capital was present in these food system organizations in their ability to support and advocate for systemic change and engage with broader policy and governance issues in the food system. Our analysis revealed advocacy for change as an important expression of political capital in Vermont's food system networks. While not all organizations engaged directly in formal advocacy, many participants described active roles in influencing food policy, supporting advocacy partners, or contributing to state level discussions. These efforts addressed structural barriers while promoting systemic change. Some participants described how their organizations directly engaged in policy advocacy. For instance, Bee shared:

> We've done a scan of local food policy incentives in the past, while working with a group of folks that are advocating for local food policy incentives in their state and we've brought that information to the state department of agriculture to try to advocate for more of those policies.

Bee further described advocacy as a purposeful tool for creating impact. Her perspective indicates that even when it was not a primary organizational focus, it remained helpful in advancing broader, long-term objectives in the food system. She said, "It's very much a big part of what we see as a lever for change and we're always figuring out where we can have the most impact."

Some organizations did not lead advocacy efforts themselves but collaborated with advocacy-focused partners. These partnerships were seen as strategic, allowing each organization to contribute its unique strengths to avoid redundancy and maximize collective effectiveness. One participant shared:

> We don't have an advocacy or policy focused position at [organization name] because we are very lucky to partner with organizations in our state that are already doing that work. So, we don't want to reinvent the wheel. We want to support folks that we know and trust in doing the work that they're fully trained and doing. (Rose)

Even for those not engaged in formal policy work, opportunities to contribute through testimony or other forms of input were seen as meaningful expressions of influence. Rita shared, "We're not an advocacy organization, [but] we do get called upon quite often to provide testimony on different things happening at the statehouse."

One participant, Rose, expressed the importance of being invited to testify and how it felt. She viewed this opportunity as a recognition of the organization's credibility and influence for change, saying:

> I think we know like whatever political capital power we have within that is recognized by everybody in the organization and you know it means something to be asked to testify. It feels like you're making a difference and you're moving towards a goal that everybody knows is a good thing.

Participants acknowledged the role of their partners as advocates especially in areas such as land use, public funding, and food justice, which highlights the interconnectedness of their missions and clients, even when advocacy itself was not their primary focus. Grace shared:

> A lot of our partners are also advocates for a variety of activities and changes that they'd like to see in, whether it's the working landscape or policy choices or funding opportunities. But that's not necessarily a place where we exist, but we work in collaboration with a lot of those partners outside of their advocacy roles, because we're working with the same clients.

Emergent, Cross-Cutting Themes

The qualitative analysis revealed several emergent themes, providing an explicit connection between participants' experiences and the CCs framework. We identified the theme of *shared work* as reflecting

elements of social capital (networks of collaboration, trust, and mutual support), human capital (experience, individual skills, professional growth, and leadership capacity), and cultural capital (organizational ethos). A second theme, *diversity gaps in institutional collaboration,* emerged as a concern that cuts across multiple capitals, intersecting with cultural and social capital, and highlighting the need for more inclusive and culturally diverse collaborative networks. The analysis below further explores how each thematic area specifically relates to these forms of CC.

Cross-Cutting Theme 1: Shared Work

Shared work refers to a collaborative approach where multiple individuals, teams, or organizations jointly contribute their efforts, resources, and skills towards completing specific tasks or achieving a common goal. This theme highlights both the strengths and challenges involved in collective efforts among food system organizations in Vermont and shows the kind of social cohesion that exists between these organizations. Participants emphasized collaboration as essential to organizational success in pursuing shared goals like funding and capacity-building. As one participant mentioned: "We do a lot of grant writing in partnership with other organizations and try to really collaborate on our strategy around funding" (Judith).

Collaboration extends beyond mutual support to strategic and tangible outcomes: shared work was reinforced by the collaborative ethos embedded deeply within organizational cultures. Participants acknowledged that collaboration was not merely beneficial but essential for achieving the organizational mission. "Collaboration is a key value of our organization. We understand that we cannot reach our mission alone. And so, it's very well understood that to accomplish our work, we must be collaborators and be good partners*"* (Rita).

However, participants also recognized challenges in collaborating with others, particularly regarding differences in organizational pace, priorities, and alignment. As one participant shared:

> There's sometimes some tension because of the necessity of wanting to work together and maybe not necessarily always going at the same speed, but also, being dependent on each other to move the process along. And we're maybe not always on the same page with the speed that we're moving at or priorities. (Rose)

Despite these challenges, ongoing efforts to strengthen communication, networking, and knowledge sharing were viewed as critical factors facilitating effective collaboration. "Generally, we do a pretty good job collaborating and supporting each other…[with] constant communication happening and then also a lot of shared learning and building together" (Mel).

Our analysis highlights shared work as a critical dimension of social capital, which can significantly influence the resilience of Vermont's food systems. Through active collaboration, such as joint projects, grant-writing, and strategic partnerships, stakeholders create interpersonal networks that facilitate rapid and effective responses to disruptions.

Cross-Cutting Theme 2: Diversity Gaps in Institutional Collaboration

Diversity gaps emerged as a critical concern that influences the inclusivity and long-term resilience of Vermont's food system. Participants described how the demographic composition and cultural norms within organizations shape the nature of collaborative efforts. One participant noted the lack of racial diversity in their organization as a limiting factor in establishing more diverse and inclusive partnerships. "We're working on collaborating on projects or grants sometimes. But I will say that the organization I work for is an all-white organization. So, there is a narrowness to like, what are the other organizations we're working with" (Matt). This observation suggests that although collaboration is taking place, it frequently happens in racially and culturally uniform networks, which can unintentionally lead to exclusion and constrain opportunities. Matt further emphasized that efforts to advance equity require critical internal reflection, especially regarding how dominant cultural norms such as white supremacy culture shape organizational practices:

> There is a culture of wanting to do more around justice and equity. In the last, I would

> say, for two years we've been recognizing that white supremacy culture is real and that the work of equity is understanding how it shows up in all our lives, and how we all benefit from dismantling it.

Taken together, the analytical themes of shared work and diversity gaps demonstrate a keen awareness among interviewees of the organizational landscape and a sense of the mutual benefits that are possible with collaboration. However, these themes also show an important level of critical reflexivity among the interviewed professionals, suggesting that they are motivated to address diversity gaps as a way to strengthen relations with other organizations, customers, and the public.

Discussion

This study examined how social, human, political, and cultural capitals contribute to building a resilient food system in Vermont. We focused on a specific case and location (the state of Vermont), taking a broader view than Flora (2018) but narrower than the regional scope of Glowacki-Dudka and colleagues (2013). While many previous CCs studies use secondary data (Deller et al., 2001; Fey et al., 2006), we utilized primary data to understand how CCs operate in resilient food systems.

In the literature, human capital is conceptualized as formal education, technical knowledge, and skills that drive economic productivity (Ali et al., 2018; Subramony et al., 2018). However, our study showed that practical, lived experience is equally important in building resilience in food systems. Beyond increased productivity from developing human capital (Li et al., 2017), this study finds that experience contributes to strategic decision-making and mentoring, as well as navigating complex situations. Our findings highlight the significant role of professional experience as a component of human capital in Vermont's food system organizations. Experience is not just something one has; rather, it is an active tool for making food systems more flexible, participatory, and resilient (Anderson, 2015). Participants' knowledge across farming, food service, nonprofit administration, and advocacy roles shows how some experiences shape their ability to respond adaptively to complex challenges. This aligns with prior research on how actors within food systems are constantly changing their practices to adapt to pressure and perturbations; these changing activities are also correlated with changes in knowledge systems (Anderson, 2015). Building more effective knowledge systems for sustainability takes time and patience, which includes the need to learn from experience and enhance human capital (Cash et al., 2003). Therefore, experience serves as a driving force for shared learning and systemic change. This suggests that professional experience is not just useful at the individual level but also plays an important role in strengthening how organizations and networks respond to complex challenges.

Our study found that political capital in Vermont's food system is built through local advocacy, policy engagement, and trust with funders. While formal political ties were found to be beneficial in corporate settings (Liu et al., 2013), this study highlights how informal relationships and consistent community engagement help organizations access grants and shape policy among nonprofit organizations. Further, this study reveals that political skill is not just an executive trait (F. Wang et al., 2024a); rather, participants demonstrated political skill through coalition-building and being responsive to local needs.

Advocacy for change represents a key aspect of political capital in Vermont's food system organizations. Political capital, as defined in the CCs framework, refers to the ability of individuals or organizations to influence standards, rules, and policy decisions that affect their communities (Casey, 2005). In this study, participants revealed that although not all organizations engaged directly in formal advocacy, many played strategic and supportive roles in shaping food policy. Political capital is not always exercised through conventional channels such as lobbying or policy leadership. Rather, it can take place through collaborative relationships, where trust, legitimacy, and partnership give organizations the ability to influence policy. This insight aligns with what Andree and colleagues (2019) describe as distributed advocacy, where organizations strategically allocate their political voice by building coalitions and reinforcing one another's strength.

Shared Work

We found shared work, defined as collaboration, mutual support, and inter-organizational network-building, to be essential to achieving organizational goals through interlocking investments in social, human, and cultural capital. Glowacki-Dudka and colleagues (2013) emphasize that social capital plays an important role in strengthening local food systems, especially when there is trust, but that social capital can be weakened by divided goals and lack of trust. This was the case in our study, evidenced by some participants' description of challenges they faced in collaborative relationships, such as different priorities, speed, and capacity among partners. Despite these challenges, our findings suggest that collaboration is deeply embedded in the organizational culture of these food system organizations. Participants' emphasis on collaborative grant-writing, shared strategic planning, and organizational co-learning serves as an important source of both knowledge and social connection, which reflects high levels of bonding social capital, as well as developing the human capital that strengthens internal networks and enhances the flow of information and resources among like-minded organizations. These insights align with observations of community-supported agriculture and how intentional communication practices promoted the development of both bridging and bonding forms of social capital (Furness et al., 2022). Similarly, in this study, participants shared that collaborative spaces are where organizations not only achieve common objectives but strengthen interpersonal relationships.

Diversity Gaps in Institutional Collaboration

While the organizations we engaged with had a strong collaborative culture and ethos, a lack of racial and cultural diversity within Vermont's food system organizations limits the scope and effectiveness of collaboration. This aligns with Compton and Meier's (2016) claim that homogeneous groups may foster strong internal ties but struggle with building broader, bridging connections. Indeed, participants acknowledged Vermont organizations' racial and cultural homogeneity as a challenge they are actively thinking about.

Diversity refers to compositional differences among people within a work unit (Roberson, 2019; Roberson et al., 2017). Our findings reveal that Vermont's food system organizations' diversity gaps are barriers to building inclusive, equitable, and resilient networks. Participants expressed concerns that the lack of racial and cultural diversity restricted the scope and inclusiveness of collaborative partnerships. As one participant noted, operating in an all-white organization restricted their ability to work with a broader range of partners, which results in networks that may reinforce existing inequalities. These findings align with broader research on diversity in organizational networks, which emphasize that homogeneous groups tend to exhibit higher levels of bonding social capital but may suffer from limited bridging social capital (Compton & Meier, 2016). The lack of racial and cultural diversity within organizational networks can not only constrain inclusive collaboration but also undermine the adaptive capacity and long-term resilience in the context of Vermont's food system organizations (Page, 2007).

Other data sources and evidence helped us to triangulate our finding that Vermont's leading food system organizations value racial diversity and justice despite the lack of diversity in the state. For example, Farm to Plate (Vermont Sustainable Jobs Fund, 2017) and NOFA-VT (2026) each have explicit racial justice statements and missions. Nonetheless, Vermont is described as the least racially diverse state in the nation (Vermont Housing Needs Assessment, 2025). Closing these diversity gaps requires intentional strategies that go beyond initial inclusion efforts. Roberson (2019) argues that inclusive organizations must move from acknowledging diversity to actively embedding it into decision-making processes, leadership structures, and partnership strategies. In the context of Vermont's food systems, this could involve setting measurable diversity targets for collaboration, establishing partnerships with organizations led by or serving communities of color (including those outside Vermont), and embedding anti-racist principles into governance and operational practices.

Thus, political influence in food systems does not rely solely on direct advocacy but is often strengthened through collective action and rela-

tionship-building. When organizations work together, whether through shared messaging, joint campaigns, or mutual support, they can extend their reach and increase their effectiveness in shaping food policy. We recommend that food system organizations continue to build strong partnerships and coalitions that allow them to act collectively, even if individual groups do not have the capacity to engage in formal policy work. Capacity-building efforts such as advocacy training, collaborative planning sessions, and policy literacy workshops can help more organizations find their voice and understand how to contribute meaningfully to policy discussions. Investment in policy infrastructure such as shared advocacy platforms, communication support, and policy analysis can help ensure that the political capital of smaller or less-resourced organizations is not overlooked. By broadening how advocacy is understood and practiced, food system organizations can make more inclusive, strategic contributions to shaping equitable and sustainable food policies. Over time, this kind of distributed political engagement helps build a more resilient food system, one where diverse voices are heard, local needs are addressed, and policy decisions are shaped by those most affected.

Our findings reflect the three core capacities of food system resilience of absorption, adaptation, and transformation as described by Tendall and colleagues (2015). Social capital, shown through shared work among Vermont's food system organizations, reflects absorption because it allows groups to respond to disruptions through shared resources and support. Adaptation is seen in the way human capital, especially professional experience and skills, helps individuals and organizations adjust their work in response to new challenges. This reflects how people draw on their past experiences and knowledge to contribute to their current situations. Finally, transformation is visible in the efforts of organizations to advocate for policy changes and address issues of diversity. These actions show how political and cultural capital are being used to influence decision-making processes and support the development of more inclusive and fair food systems. Community capitals not only help organizations cope with challenges; they also contribute to longer-term changes in the food system.

Implications

The findings of this study have several implications for strengthening food system resilience. In particular, they highlight opportunities for food system organizations, funders, and policymakers to better cultivate experiential knowledge, support collaborative work, and promote diversity and inclusion. The following sections discuss these implications and their potential application within food system organizations.

Cultivating Experiential Knowledge

Food system organizations should treat experience as a key part of human capital that contributes to long-term resilience. Experience can support better decision-making, promote learning from past successes and failures, and improve coordination across different sectors of the food system. Based on our findings, we recommend that organizations create more intentional ways to share and apply experiential knowledge. This can include mentorship between newer and more experienced staff, open discussions about lessons learned, and regular opportunities for staff to reflect on their work. Funders and policy leaders can help by supporting professional development programs and by recognizing experience (not just formal education) as an important qualification in hiring and leadership roles. In the long term, valuing and using experience in this way can help build a food system that is more resilient. It allows organizations to adapt more effectively, strengthen relationships, and respond to unexpected challenges with insight and confidence.

Sharing Work

Organizations that invest time and energy into building and maintaining relationships are more likely to be successful in working across boundaries. To support this, organizations should set aside dedicated time for joint planning, shared training sessions, and frequent communication. These practices can help ensure that differences in priorities or capacity do not become barriers to collaborations that play an important role in creating a more resilient food system. When organizations trust one another and communicate effectively, they are better equipped to respond to challenges, adapt to change, and

coordinate responses during times of disruption. Therefore, supporting collaboration is not only valuable for immediate project outcomes but also a long-term investment in building a food system that is more sustainable, equitable, and adaptable.

Building Diversity

Without these intentional efforts, Vermont's food system organizations may continue to reflect and reproduce existing social inequalities, limiting their ability to respond to complex challenges that represent the full range of community needs. A lack of diversity not only narrows the pool of knowledge and experience available to organizations but also reduces their legitimacy and reach in broader, diverse communities. To address these challenges, Vermont food system organizations should adopt equity-centered collaboration frameworks that prioritize inclusion. This includes conducting equity audits of current partnerships, creating safe spaces for cross-cultural dialogue, and ensuring that leadership roles reflect the demographic diversity of the wider community. Training programs on cultural humility, anti-racism, and inclusive governance can help shift internal culture and practice. Funders and policymakers have an important role to play by requiring equity benchmarks in grant criteria and supporting organizations that demonstrate authentic engagement with underrepresented communities. Such support not only fosters justice and representation but also builds a more resilient Vermont food system, one that draws strength from a broad base of perspectives, adapts to shifting social and economic conditions, and ensures that food system strategies are responsive, inclusive, and sustainable over the long term.

Limitations

This study has several limitations related to the study sample and qualitative research design. The following sections discuss limitations concerning the size and composition of the sample, as well as methodological considerations related to qualitative rigor and the analytical process.

Sample

One limitation is that the study relied on a modest number of semi-structured interviews with professionals in food system organizations. While the sample provided rich insights, it may not capture the full range of perspectives, especially those of smaller community-based organizations or other state government agencies. After 10 interviews, we achieved saturation (Ahmed, 2025; Duran et al., 2006; Jennings & Yeager, 2025; Tong et al., 2007). Our participants' familiarity with the research team and subject matter may have limited the breadth of responses and insights gained. We acknowledge that counting and correlating key themes from responses in a larger sample, ideally outside of Vermont, would add to the reliability of our findings. Future research could further explore how to address diversity gaps that were identified in food system networks and investigate the long-term impacts of different management practices on market resilience.

Qualitative Rigor

While we implemented and documented many recommended steps to ensure rigor—namely noting research gap, description of sampling process, use of memos and software, mentoring, positionality of lead author and triangulation strategies (Ahmed, 2025; Duran et al., 2006; Jennings & Yeager, 2025; Tong et al., 2007)—there are further steps that would have strengthened our study. The use of multiple coders, greater triangulation, and member checking transcripts with subjects are practices that we shall endeavor to incorporate in future qualitative work.

Conclusion

Our research contributes to a deeper understanding of community capitals' role in food system resilience and offers practical insights for policymakers and practitioners working to strengthen local food systems. We know of no other study that used the CCs model to understand the norms and policies of food system organizations and state agencies. We hope to contribute to a conversation about how this model can help understand these organizations. Furthermore, while Vermont is a small state, many of its programs and efforts are innovative and have been studied and, in some cases, adopted or emulated by other states. We believe there are lessons to be learned and applied

elsewhere from Vermont's robust nonprofit food systems sector. Building resilient local food systems requires leveraging various forms of community capital. As Vermont continues to lead in local food system development, these findings can inform policies and initiatives to strengthen food security, support local agriculture, and enhance community well-being in the face of ongoing challenges and disruptions.

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Bridging cultural divides: Culture and acculturation in Latino/a–service provider interactions

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Abstract

This case study examines how culture and acculturation shape interactions between Latino/a immigrant farmers and service providers in Missouri. Grounded in Valdivia et al.'s (2012) framework on capital creation and complemented by Bourdieu's (2012) concepts of habitus and field, the research draws on focus groups and interviews with Latino/a immigrant farmers and agricultural service providers across Southwest and Central Missouri. The analysis reveals seven interconnected themes spanning institutional disconnect, trust barriers, time administration, communication, market entry, financial practices, and gender dynamics. Acculturation emerged as a bilateral dynamic in which both farmers and service providers interpret each other's behavior through institutional logical

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The authors declare no conflicts of interest.

frameworks that are culturally distinct. Farmers' prior experiences in Latin America, including encounters with institutional corruption and financial instability, shaped their wariness toward U.S. institutions, while service providers' habitus (the values, beliefs, and motivations they absorb through professional training and social position) led them to misread farmer behavior as cultural deficiency rather than adaptive strategy. To organize these dynamics, the study develops a *bidirectional acculturation interface:* a conceptual framework that extends acculturation theory (Berry, 1997) to the farmer–service provider relationship by integrating Valdivia et al.'s capital creation framework with Bourdieu's concepts of habitus and field. The framework identifies two mechanisms that shape outcomes: a misalignment mechanism that blocks farmers' conversion of existing types of capital into institutional support and an alignment mechanism that enables conversion when service providers recognize the capitals that farmers bring. Findings underscore the need for culturally responsive services, revised eligibility criteria accommodating small-acreage and dispersed operations, accessible financial products, and institutional attention to the context of reception that shapes farmers' willingness to engage.

Keywords
Latino/a immigrant farmers, Hispanic farmers, bidirectional acculturation, farmer–service provider interactions, capital creation, context of reception, habitus, livelihood strategies, Midwest

Introduction

The U.S. is home to over 112,000 Latino/a farmers collectively managing approximately 37 million acres of farmland (U.S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2024). The Midwest is witnessing a subtle yet notable demographic shift, characterized by a growing number of farmers and ranchers (henceforth identified as farmers) who identify as Latino, of Spanish descent, or Hispanic. This demographic shift introduces new challenges and opportunities in agriculture, where formal and informal institutions shape access to resources and expertise, allocate technical support, and create the conditions necessary for developing sustainable and economically viable operations (North, 1991, 1996; Valdivia et al., 2021). As the number of Latino/a immigrant farmers grows and their land management expands, understanding how institutions—including government agricultural agencies such as the USDA Farm Service Agency and Natural Resources Conservation Service, the Farm Credit System, commercial agricultural lenders, and university extension programs—support their integration and success becomes increasingly important. Institutions are human-made constraints that shape socioeconomic and political interactions, defining the rules that govern how participants engage (North, 1991, 1996). While institutions frame the reality we operate in, belief systems reflect our internal understanding of that reality (North, 2008). Stalled progress in many groups often stems from restrictive institutional frameworks that fail to incentivize economic expansion (Acemoglu et al., 2001; Acemoglu & Robinson, 2012; Minkoff-Zern, 2018, 2025; North, 1994).

Culture represents the accumulated knowledge and shared learning passed across generations that informs individuals' actions and livelihoods (Smith, 1966). It is deep-rooted and long-lasting, shapes behavior, and evolves slowly over extended periods (North, 1990, 1991; Williamson, 2000). Acculturation describes the process by which newcomers adapt to their new community's cultural norms, adjusting to varying degrees to both the surrounding culture and their culture of origin (Berry, 1997; Schwartz et al., 2010; Valdivia et al., 2012), and therefore influences not only social integration but also economic decision-making within institutional environments. Immigrants' acculturation strategies can therefore reflect a combination of adjustments to both their native and host cultures, shaping their social integration and economic participation (Leiva et al., 2025; Valdivia et al., 2012) and, consequently, their capacity to contribute and thrive.

This broader understanding of institutional impact sets the stage for examining the specific situation of Latino/a farmers in this study. These farmers are immigrants and native Spanish speakers with varying lengths of U.S. residence, some arriving directly to the Midwest from their home countries, and others migrating from various U.S.

regions where they had previously worked as farm laborers or factory workers, or in service industries. Drawn by the area's high-quality soil, they supplement their agricultural income with diverse livelihood sources, such as operating small restaurants or running other small businesses. Before migrating to the U.S., all engaged in small-scale agricultural production in their home countries. While the category "Latino/a" provides a useful analytical lens, the populations it encompasses carry distinct migration histories, agricultural traditions, and institutional experiences.

This background provides essential context for understanding the objectives that influence farmers' agricultural decisions as they transition to more established operations. However, the conventional assumption of farms prioritizing profit maximization does not fully capture the breadth of objectives guiding Latino/a immigrant farmers' early career decisions. While many farmers operate to maximize profits, other goals such as asset expansion, risk minimization, lifestyle maintenance, farm size maximization, and debt avoidance also play important roles (Drummond & Goodwin, 2011). For Latino/a immigrant farmers, early farming stages focus less on financial gain and more on family involvement, building social networks, and ensuring food quality and security (Flora et al., 2012; Huerta-Arredondo et al., 2023; Lewis, 2009; Thompson, 2011). As they become more established, managing marketing, financial, and production risks becomes critical (García-Pabón, 2011), with increased investments in agriculture and training significantly associated with market engagement (Leiva et al., 2025). This complexity underscores the diverse motivations and challenges Latino/a farmers face as they navigate the agricultural sector.

This study interviewed both farmers and service providers across governmental and commercial sectors to better understand how culture and acculturation shape farmers' interactions with resource providers. While acculturation theory has long focused on one-directional immigrant adaptation, a smaller body of work has recognized the bidirectional nature of cultural contact, whether through bidimensional frameworks that track heritage and host-culture orientations (Berry, 1997) or interactive models that theorize reciprocal change in both groups (Bourhis et al., 1997). This bidirectional dynamic has not been examined in the agricultural institutional context, where farmers and service providers occupy distinct positions in the same field. This study addresses that gap by examining how culture and acculturation jointly shape the interface between Latino/a immigrant farmers and agricultural service providers. Integrating Valdivia et al.'s (2012) framework on capital creation strategies with Bourdieu's (1990) concepts of habitus and field, the analysis reveals how the culturally distinct orientations of both farmers and service providers—each operating within different institutional contexts—condition their interactions and outcomes. Across seven themes, a consistent pattern emerges: misalignment between these cultural frames constrains farmers' ability to convert existing capital into institutional support and economic advancement. To organize these dynamics, the study develops a conceptual framework—*the bidirectional acculturation interface*—that extends acculturation theory to the farmer–service provider relationship. Findings carry direct implications for culturally responsive service design, revised program eligibility criteria, and institutional approaches that recognize the assets Latino/a immigrant farmers contribute.

Conceptual Framework

Valdivia et al. (2012) provide the primary theoretical foundation for this analysis, exploring capital creation strategies among Latino/a newcomers in rural Midwestern communities. Their framework examines how immigrants utilize their assets—spanning economic, human, social, and cultural capitals—to establish sustainable livelihoods. Central to this framework is the recognition that cultural and social capitals play pivotal roles in shaping economic opportunities: immigrants' life experiences, social networks, and knowledge of local institutions directly influence their integration into new environments. Leiva et al. (2025) and Valdivia et al. (2012) demonstrate that acculturation patterns—particularly the degree to which immigrants maintain connections to both their heritage culture and the host culture—significantly affect resource access, network building, and economic success.

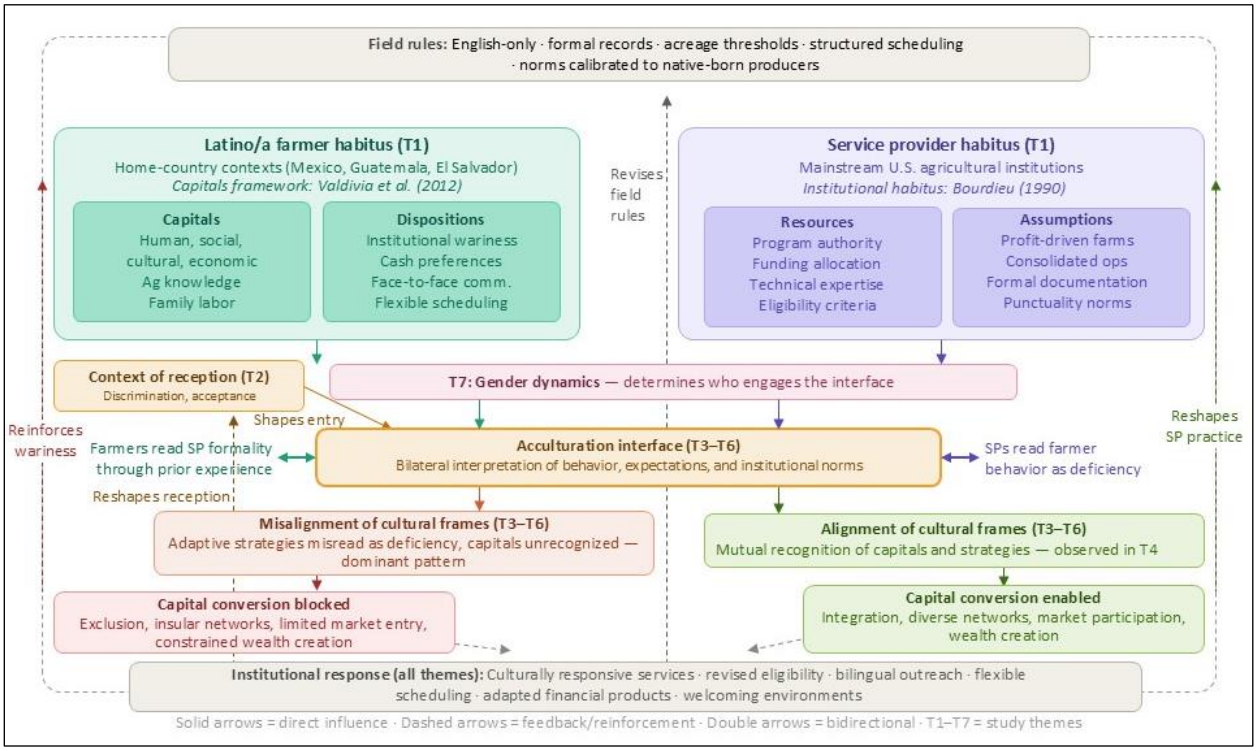
This framework is complemented by Bourdieu's (1990) related concepts of habitus and field. Habitus refers to durable dispositions formed from early life experiences in specific social contexts, influencing how individuals perceive opportunities and navigate institutions. These patterns of thought and behavior, shaped by factors like family upbringing and education, are both stable and adaptable, subtly guiding personal actions. Field describes networks of positions within a social space, each governed by its own rules and norms—in this case, the U.S. agricultural sector, with its particular institutional expectations and practices.

The Bidirectional Acculturation Interface

Integrating these frameworks yields a novel conceptual model that extends acculturation theory (Berry, 1997) beyond its traditional focus on one-directional immigrant adaptation to analyze how culture and acculturation jointly shape farmer–service provider relationships (Figure 1). The model positions the acculturation interface at the center, where the culturally shaped habitus of both Latino/a immigrant farmers and agricultural service providers meet in the U.S. agricultural field. Farmers arrive at this interface carrying capitals and dispositions formed in the institutional contexts of their home countries, while service providers bring institutional resources and assumptions shaped by mainstream U.S. agricultural norms. The context of reception, including experiences of discrimination or acceptance, and gender dynamics and language proficiency mediate who engages the interface and under what conditions. The model is explicitly bidirectional: farmers interpret service provider formality through the lens of prior institutional

Figure 1. The Bidirectional Acculturation Interface

The framework extends acculturation theory to the farmer–service provider relationship by positioning both parties as operating from culturally shaped habitus that meet in the U.S. agricultural field. Context of reception, gender dynamics, and language proficiency mediate entry into the acculturation interface, which produces two possible paths: a misalignment mechanism in which cultural frames fail to align and block capital conversion, and an alignment mechanism in which service providers' recognition of the capitals and strategies farmers bring enables it. Dashed arrows represent feedback loops through which outcomes reinforce or reshape dispositions, institutional practices, and field rules. Themes 1–7 are mapped to the model components from which they emerge.



experiences, while service providers interpret farmer behavior through the lens of conventional agricultural norms.

When these cultural frames misalign, farmers' adaptive strategies are misread as deficiency, blocking capital conversion. Mutual recognition of each party's capitals and strategies brings alignment, which enables capital conversion and supports integration into diverse institutional networks. Feedback loops illustrate how outcomes are self-reinforcing: exclusion deepens institutional wariness, while positive engagement reshapes both service provider practice and the broader context of reception. This integrated model enables researchers to examine how farmers modify their native farming techniques to align with U.S. agricultural practices, how culture and acculturation influence economic behaviors, and how market engagement dynamics develop. Understanding support from local institutions can also reveal how policies and economic incentives influence Latino/a immigrant farmers' decisions and their integration into the local agricultural economy.

Culture, Acculturation, and Trust Dynamics

Previous research demonstrates that maintaining connections to both Anglo and heritage Latin American cultures—what Valdivia et al. (2012) describe as an integration or bicultural acculturation strategy—significantly improves immigrants' access to resources, network building, and overall economic success compared to one-way assimilation into Anglo culture alone. In this framework, orientation toward heritage culture is tracked through "Spanish acculturation" measures (reflecting continued engagement with Spanish language use), while orientation toward the host culture is tracked through "Anglo acculturation" measures. Language serves as a well-established proxy for measuring acculturation (Berry, 1997; Chiswick & Miller, 2001; Portes & Rumbaut, 2006). Leiva et al. (2025) applied these acculturation measures for the first time to examine market entry and agricultural sales among Latino/a immigrant farmers. Traditional one-way assimilation can adversely affect Latino/a immigrants by enforcing dominant cultural norms, marginalizing Latino/a cultural identities, and potentially leading to internalized discrimination in the community (Feagin & Cobas, 2014). In the Midwest, both Anglo and Spanish acculturation (encompassing language usage with relatives and acquaintances, spoken and written linguistic skills, and proficiency in electronic media) are significantly associated with a lower likelihood of market entry, by 20% and 26%, respectively (Leiva et al., 2025). Farmers more acculturated to Anglo norms often pursue more diverse livelihoods and off-farm employment, allocating fewer hours to farming, while those with stronger Spanish acculturation may face communication barriers with English-speaking agricultural institutions.

For Latino/a immigrant farmers engaged in market activities, variables such as the scale of land cultivated, workforce size, personal plus familial income, and hours invested in farming are linked to significant increases in agricultural sales (Leiva et al., 2025). Conversely, higher degrees of Anglo acculturation and farmers' negative views about community context (including experiences of discrimination, lack of acceptance, or social isolation) are significantly linked to reductions in agricultural sales. Socially, the sense of being accepted by the community significantly influences professional engagement and general well-being. Systemic racism, influenced by racial framing, frequently places Latino/a immigrants in a disadvantaged position, affecting their economic activities (Feagin & Cobas, 2014; Minkoff-Zern, 2025; Valdivia et al., 2008).

These complex dynamics of acculturation and economic participation underscore the broader social challenges Latino/a immigrant farmers face and set the stage for exploring effective engagement strategies. Successful engagement with Latino/a immigrant farmers hinges on cultural competence, avoiding stereotypes, and recognizing individual needs (García-Pabón, 2011; García-Pabón & Ostrom, 2015; Huerta-Arredondo et al., 2023).

Building trust between Latino/a immigrant farmers and institutional actors (whether government agencies, nonprofit organizations, university extension programs, or commercial lenders) is crucial and can be particularly challenging. The nature of trust barriers varies across these institutional contexts. Such wariness may be informed by prior

experiences with corruption, inefficiency, or unresponsive bureaucracies in participants' countries of origin (Mexico, Guatemala, and El Salvador). Research documents the corrosive relationship between corruption and institutional trust in Mexico, specifically (Morris & Klesner, 2010), and across several Latin American countries, including El Salvador, where corruption erodes confidence in public institutions, political legitimacy, and trust in civil servants (Hauk et al., 2022; Seligson, 2002). For farmers who carry these experiences, the transition to U.S. institutions represents a significant shift, one where trust can potentially be rebuilt through positive, consistent interactions with local agricultural support systems.

Methodology

This section describes the study's case study design, the focus groups and interviews conducted with farmers and service providers, the process of participant engagement, and the analytical steps through which the seven themes were developed.

Data Gathering and Evaluation

This study employed a qualitative case study methodology to examine how culture and acculturation shape the interactions between Latino/a immigrant farmers and agricultural service providers in Missouri. This context is well-suited to "how" and "why" questions where researchers have limited control over events (Yin, 2009). The case is defined as the farmer–service provider interface within Missouri's agricultural institutional landscape, encompassing both Southwest and Central regions. Case studies enable in-depth examination of contemporary phenomena within their real-world context, particularly when boundaries between phenomenon and context are not clearly defined (Feagin et al., 1991; Merriam, 1988; Tellis, 1997). This approach captured the nuances of participants' activities, attitudes, and motivations from their own perspectives.

A bilingual research team conducted interviews and focus groups. The research team was composed of researchers of Hispanic, bicultural (Hispanic and Anglo), and Anglo backgrounds with over 25 years of combined experience working with immigrant communities in the Midwest. Two service-provider focus groups (n = 21) and two farmer focus groups (n = 32) were conducted across Southwest and Central Missouri. The team's established connections with Latino/a farming communities in the study regions facilitated participant trust and recruitment. Farmer focus groups and interviews were conducted in Spanish or English based on participants' preferences, while all service provider sessions were conducted in English. Sessions took place in neutral settings, including community centers and churches. Participants received a modest monetary incentive for their time. This cultural and linguistic familiarity enabled candid discussion in settings where participants felt at ease. At the same time, the inclusion of Anglo researchers on the team provided an additional analytical perspective that guarded against assumptions rooted in shared cultural familiarity. The team was conscious that proximity to participants' experiences could introduce interpretive bias. To mitigate this, our analytical process (Figure 2) incorporated deliberate checks: independent analysis of each focus group dataset; systematic identification of potential biases; and a comprehensive review step designed to reevaluate methods, findings, and conclusions for shortcomings and gaps. This process follows the six-step sequence developed by Castro (2020) and draws on Braun and Clarke (2006) and Green et al. (2007), to which we added the seventh comprehensive review step as an original methodological contribution of this study. These procedural safeguards helped ensure that the analysis reflected participants' voices rather than the team's preconceptions.

To ensure validity, the study used triangulation across data sources, investigators, theories, and methods, as recommended by Feagin et al. (1991) and Yin (2009). Households were identified through purposive sampling across multiple locations, in collaboration with the University of Missouri's Cambio Center and regional partners. Farmer participants were selected based on three criteria: self-identification as a Latino/a immigrant, active farming operations in Missouri, and ownership or lease of agricultural land. Service provider participants included public- and private-sector professionals working with small producers in the targeted study areas.

Participants were recruited for focus groups, interviews, or both. The primary study areas included Lawrence and Barry counties in Southwest Missouri and Saline and Pettis counties in Central Missouri. Including two geographically and demographically distinct regions allowed the research team to compare emerging themes across different settlement patterns, agricultural activities, and community contexts. This strengthens the validity of the findings by confirming that key themes were consistent across settings rather than specific to a single location or population group (Feagin et al., 1991; Yin, 2009). This study was approved by the University of Missouri Institutional Review Board (Protocol No. 2005869).

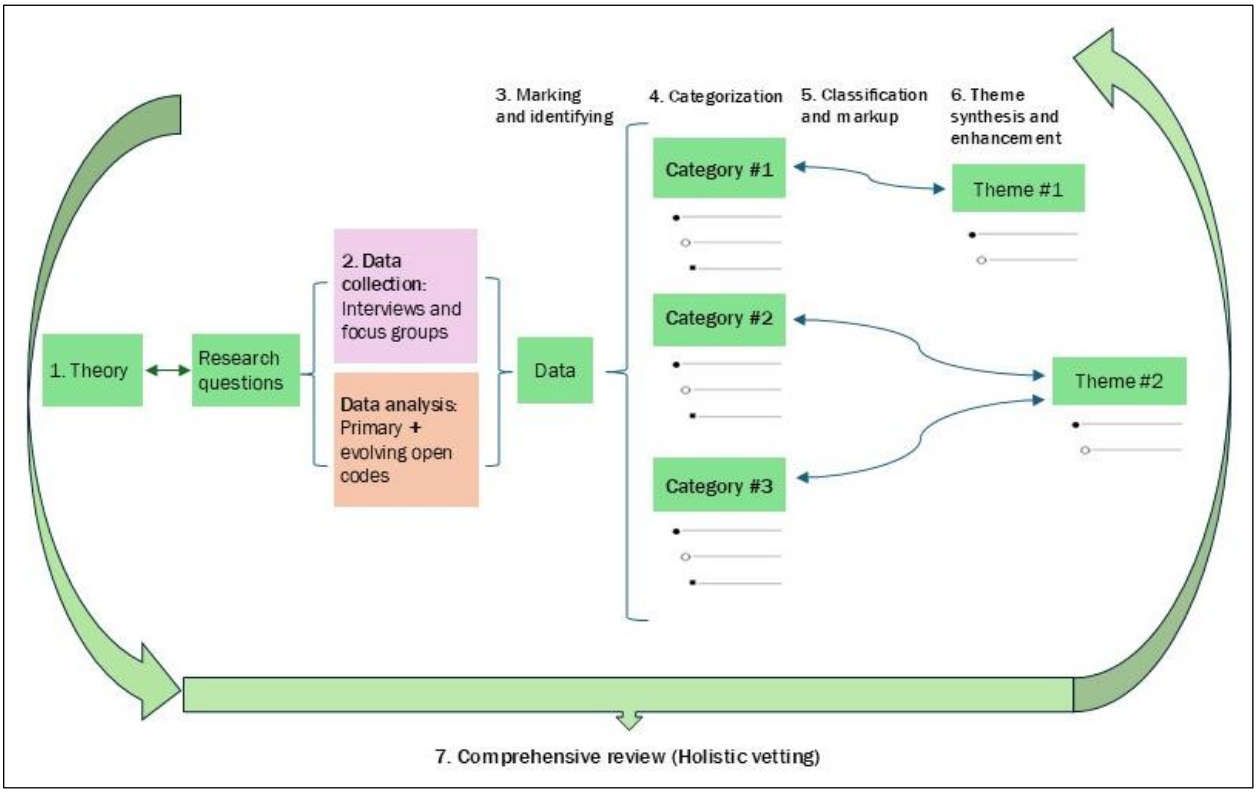
Participant Engagement and Feedback

Focus groups with service providers provided valuable insights into their knowledge, skills, and experiences working with farmers. Two service provider focus groups were conducted, comprising 21 participants across Southwest and Central Missouri. Participants included staff from the USDA Farm Service Agency (Common Programs, Farm Loans, Conservation, and Price Support units), the USDA Natural Resources Conservation Service, and the Farm Credit System (a nationwide network of borrower-owned cooperative lending institutions that provides credit to agriculture and rural communities). Participants also included agricultural commercial lenders and agribusiness and youth program specialists from university extension programs. This diverse mix of representatives ensured that multiple viewpoints were captured. These focus groups revealed both the strengths service providers bring and the challenges they face when assisting Latino/a immigrant farmers.

Of the 32 farmer participants, approximately 50% were Mexican, 30% Guatemalan, and 20% Salvadoran. Roughly half farmed in Southwest Mis-

Figure 2. Data Analysis Process

The first six steps are adapted from Castro (2020), Braun and Clarke (2006), and Green et al. (2007). The seventh step, a comprehensive review process, is an original methodological contribution of this study that systematically reevaluates methods, findings, and conclusions against the assembled evidence, identifying and addressing potential shortcomings, biases, or gaps before results are finalized.



souri ($n \approx 15$), where participants were predominantly Mexican and engaged in small-scale cattle operations, and half farmed in Central Missouri ($n \approx 17$), where the population was more diverse, including Mexican, Guatemalan, and Salvadoran participants engaged in crop production. Farmers managed operations ranging from two to 35 acres. Length of residence in the U.S. varied from five to 45 years, and all participants had agricultural experience in their countries of origin prior to migration. All discussions and interviews were audio-recorded to ensure accurate documentation. Two bilingual native Spanish speakers reviewed the recordings to verify transcription accuracy and enhance data interpretation quality. All Spanish-language transcripts were translated into English by native Spanish-English bilingual members of the research team to ensure accuracy and preserve contextual meaning. Detailed written notes were maintained during all sessions to capture additional contextual insights.

Data Analysis

The analysis combined deductive approaches drawn from Braun and Clarke (2006) and Green et al. (2007) with inductive methods to discover naturally emerging patterns, ideas, and connections in the data. The inductive analysis specifically examined factors influencing change, adaptation strategies, and the perspectives of both farmers and service providers. The research team conducted coding collaboratively through detailed examination of text and keywords, following the seven-step analytical process depicted in Figure 2. This combined approach helped reveal unique and unexpected topics that enriched the findings.

Transcribed texts were reviewed multiple times to document significant changes and adjustments that respondents reported. This careful documentation supported the development of descriptive codes, their organization into categories, and the identification of themes. Spreadsheets were used to organize data systematically and facilitate thematic analysis. Qualitative methods captured the personal, narrative dimensions of participants' experiences. Figure 2 depicts the data analysis process. The first six steps follow the sequence developed by Castro (2020), drawing on the thematic analysis approaches of Braun and Clarke (2006) and Green et al. (2007): reviewing theoretical frameworks and research questions, gathering and examining data, identifying relevant information, organizing and labeling data, classifying and marking up the labeled data, and synthesizing and refining themes. To this established sequence we added a seventh step—a comprehensive review process—that systematically reevaluates methods, findings, and conclusions against the assembled evidence. This additional step, an original methodological contribution of this study, strengthens the six-step approach by proactively identifying and addressing potential shortcomings, biases, or gaps before results are finalized.

Following Castro's (2020) recommendations, we present our findings through quotations, data summaries, and integrated analysis. This structured presentation clarifies underlying themes while connecting them to scholarly evidence from related research. We derived the themes by identifying common patterns across the data through both deductive and inductive reasoning, without predetermining their number or criteria. Deliberate steps ensured that preconceived perspectives did not bias the analysis, with potential biases actively identified and addressed throughout the process. Each of the four focus group datasets was analyzed independently. Analytical saturation was reached when no new thematic categories emerged. Through careful organization and coding, relevant themes emerged as shown in Figure 2. This rigorous process led to seven themes, which Table 1 describes briefly.

Findings

Analysis of focus groups and interviews with the 32 farmer and 21 service provider participants revealed seven interconnected themes reflecting how culture and acculturation shape interactions between Latino/a immigrant farmers and service providers. The seven themes correspond to distinct components of the bidirectional acculturation interface (Figure 1): Themes 1 and 2 concern entry conditions that shape whether farmers approach the interface at all, Themes 3 through 6 describe the interaction mechanics through which culturally shaped habitus meet within the U.S. agricultural

Table 1. Themes Highlighting the Role of Culture and Acculturation in Shaping the Interaction between Latino/a Immigrant Farmers and Service Providers

This table summarizes key themes from the study, illustrating how cultural and acculturation dynamics influence the interactions between Latino/a immigrant farmers and service providers.

Theme	Description
Theme 1: Disconnect Between Service Providers and Immigrant Latino/a Farmers	Cultural barriers hinder collaboration between service providers and immigrant Latino/a farmers. Service providers often lack awareness of Latino/a agricultural backgrounds and capabilities, while farmers remain unfamiliar with available programs and resources. Stereotypes portraying Latino/a immigrants primarily as laborers rather than agricultural entrepreneurs contribute to this disconnect. Enhancing cultural proficiency and understanding of acculturation processes can bridge these gaps.
Theme 2: Trust Barriers Between Latino/a Farmers and Service Providers	Significant trust issues stem from farmers' prior negative experiences with institutions in their countries of origin, where corruption and inefficiency have eroded confidence in formal systems. This habitus of institutional wariness transfers to U.S. contexts, creating hesitancy toward government agencies and formal documentation. Discrimination and exclusion encountered in U.S. contexts compound this wariness, making trust a specific mechanism through which context of reception shapes whether farmers engage the institutional interface.
Theme 3: Divergent Time Administration Between Latino/a Immigrant Farmers and U.S. Service Providers	Contrasting approaches to time create barriers to effective service provision. Latino/a immigrant farmers often manage smaller farms while balancing off-farm employment, household responsibilities, and family obligations—constraints that shape their scheduling flexibility. Service providers operating within structured schedules may misinterpret these time management differences as cultural preferences rather than practical adaptations to livelihood demands.
Theme 4: Communication and Language Barriers Between Latino/a Farmers and Service Providers	Language proficiency and cultural communication styles shape access to networks, training opportunities, and institutional support. Many Latino/a immigrants face English proficiency challenges, while high-context communication norms emphasizing relationship-building and face-to-face interaction differ from low-context U.S. institutional practices. Federal agencies have historically provided limited Spanish-language resources, and availability continues to vary across agencies and local offices.
Theme 5: Market Entry and Risk Mitigation Challenges for Latino/a Farmers	Latino/a immigrant farmers face challenges with market access, product management, direct selling, and price volatility. Prior experiences with intermediary-dominated transactions in home countries shape their expectations and strategies. Structural access barriers—not individual capacity—account for many market engagement gaps, including limited marketing knowledge, business expertise, and technical education.
Theme 6: Financial Practices and Livelihood Strategies Among Latino/a Immigrant Farmers	Latino/a immigrant farmers approach financial decisions in ways that differ from conventional U.S. practices. Prior experiences with economic instability and financial exclusion inform preferences for cash transactions and caution toward formal banking. Distinctive livelihood strategies include purchasing small plots across different locations, diversifying on-farm and off-farm income, and gradual transitions into formal markets. U.S. agricultural programs often overlook small-scale, diversified operations.
Theme 7: Cultural Gender Roles Among Latino/a Immigrant Farmers and Service Providers	Gender dynamics within Latino/a immigrant households shape patterns of social capital development and network access. Cultural norms around gender roles influence which family members communicate with institutional representatives and access agricultural resources. While traditional patriarchal structures persist in some households, gender ideologies are evolving toward more progressive norms emphasizing respect, fairness, and affection. Gender dynamics thus shape who enters the acculturation interface in the first place, determining whose institutional social capital accumulates through interactions with service providers.

field to produce misalignment or alignment, and Theme 7 addresses gendered access to the interface itself.

Theme 1: Disconnect Between Service Providers and Immigrant Latino/a Farmers

Profound cultural barriers hinder effective collaboration between service providers andimmigrant Latino/a farmers. Valdivia et al. (2012) emphasize that the context of reception—how receiving communities perceive and interact with newcomers—shapes immigrants' capacity to build social networks and access resources. When service providers lack understanding of Latino/a farmers' backgrounds and aspirations, they inadvertently create an unwelcoming context that limits farmers' integration into the agricultural field. One service provider reflected on this disconnect:

> I really didn't know that there were a lot of Hispanic Latino farmers at all, I just thought that they worked in industry. It's a big challenge to understand where people come from, like a third-world country to a place like this. —Service Provider, Central Missouri

This perception reveals deep-rooted stereotypes that misrepresent Latino/a immigrants primarily as laborers rather than potential agricultural entrepreneurs. Such assumptions reflect what Bourdieu (1990) describes as the habitus of service providers: internalized dispositions shaped by mainstream U.S. agricultural institutions that historically centered white, native-born farmers as the default agricultural producer. This institutional habitus, reinforced through training programs, eligibility criteria, and outreach practices designed for native-born producers, generates blind spots that prevent service providers from recognizing the cultural, social, and human capital that immigrant farmers bring to the agricultural field. From the farmers' perspective, this disconnect manifests as exclusion from institutional knowledge and support networks. A farmer expressed frustration with the lack of accessible pathways:

> I know that USDA has programs, but I don't know anything about the office. … I mean, we are unknowledgeable about these things. I can assure you that I know people in this area that would like to know how to start their own farms, but they don't know where to go or how to commercialize and be given support more than anything. —Farmer, Central Missouri

Another farmer from Southwest Missouri echoed this sense of exclusion: "Frankly, the one who'll still receive help is the American farmer. For us Latinos, maybe there are some programs, but us, we haven't gotten it yet." These experiences illustrate what Valdivia et al. (2012) describe as the disconnect between institutional frameworks and the lived realities of Latino/a newcomers. Latino/a farmers often encounter numerous challenges, including discrimination, limited networking opportunities, and minimal involvement in agricultural policy discussions (García-Pabón, 2011; Gonzalez & Jeanetta, 2013; Lewis, 2009; Minkoff-Zern, 2025). Valdivia et al. (2012) found that when newcomers perceive the community climate as negative (that is, marked by discrimination or lack of acceptance) they develop narrower social networks limited primarily to family and friends. This constrains their wealth creation opportunities. These patterns reflect not merely individual biases but systemic institutional structures that have historically marginalized farmers of color and perpetuate barriers, even when individual service providers hold welcoming intentions (Minkoff-Zern, 2025).

Enhancing the cultural proficiency of service providers and enriching their understanding of acculturation processes are essential steps toward bridging this disconnect. By recognizing the diverse forms of capital that Latino/a farmers contribute, including agricultural knowledge from their home countries and family labor practices (Minkoff-Zern, 2019), strong social networks, and entrepreneurial drive (Valdivia et al., 2012), service providers can more effectively support their integration and success in the agricultural sector.

Theme 2: Trust Barriers Between Latino/a Farmers and Service Providers

Significant trust barriers impede meaningful relationships between Latino/a immigrant farmers and

service providers. Building on Theme 1's discussion of the context of reception (Valdivia et al., 2012), trust barriers operate as a specific mechanism through which unwelcoming reception translates into reduced institutional engagement. Service providers recognized that farmers often hesitate to engage with formal documentation and institutional processes: "They just want to shy away from it, from what I know. When you mention anything that has to do with putting things on black and white paper, they just kind of shy away from it, until they get that trust." Service providers directly linked this wariness to farmers' prior experiences, noting that farmers were "afraid of governmental programs" and would avoid any process involving formal documentation. Farmers' own accounts reinforced this pattern. As one farmer in Central Missouri described, institutional distrust shaped financial behavior: "Before, anyone who wanted to go to a bank wouldn't go because they were scared, and they would hide all their money in their cushions and mattresses." Another, from Southwest Missouri, expressed the resulting sense of isolation from support systems: "Those of us that don't have enough, where do we go? Whom do we ask for help?" These accounts are consistent with research documenting the erosion of institutional trust in parts of Latin America due to corruption, financial instability, and unresponsive bureaucracies (Hauk et al., 2022; Morris & Klesner, 2010; Seligson, 2002). These dispositions are further reinforced when farmers encounter discrimination and exclusion in the U.S. context itself (Minkoff-Zern, 2025; Minkoff-Zern & Sloat, 2017), compounding the institutional wariness they carry from prior experiences.

A farmer from Southwest Missouri recounted a discouraging experience: "I went to ask in an office. I think it's called 'USDA' or something like that. I urgently needed a *bordo* [water dam]. They hardly looked at me. They ignored me." The institutional affiliation of public service providers adds another layer of complexity. As one service provider acknowledged:

> One challenge we have, which you already kind of mentioned, is that we are part of the government. That kind of puts up a barrier that they don't want to come in the office, let alone hear what we have to say. —Public Service Provider, Central Missouri

Valdivia et al. (2012) found that trusted community institutions such as churches, schools, and employers can serve as bridges between newcomers and receiving communities, facilitating access to higher-quality information and broader networks. Building trust through these intermediaries represents a promising strategy for aligning institutional practices with farmers' cultural preferences. By understanding these trust dynamics, service providers can develop more effective outreach strategies that acknowledge farmers' prior experiences while creating pathways to productive collaboration and successful market integration.

Theme 3: Divergent Time Administration Between Latino/a Immigrant Farmers and U.S. Service Providers

Contrasting approaches to time administration between Latino/a immigrant farmers and U.S. service providers create barriers to effective service provision. Farmers' time allocation reflects the diverse livelihood strategies characteristic of immigrant newcomers with limited institutional and financial capital (Valdivia et al., 2012). These constraints directly influence how farmers allocate their time across multiple demands.

Latino/a immigrant farmers in the Midwest often manage smaller farms, averaging 23 acres, and face numerous constraints, including limited funding, insufficient training, and varying literacy levels in both English and Spanish. Many farmers balance agricultural work with off-farm employment (Leiva et al., 2025), alongside household responsibilities and family obligations. This reality shapes their approach to scheduling, which may appear more flexible compared to the structured expectations of U.S. agricultural services. One farmer described this constant juggling:

> My coworkers ask, "What are you doing this weekend?" Work. "Tomorrow?" Work. "Day after?" Work. They joke, "Hey, your wife will leave you because you don't have time for her." —Farmer, Central Missouri

This scenario illustrates the challenging balance many Latino/a farmers maintain, often working on their farms during evenings and weekends while holding other jobs. From the farmers' perspective, inflexible institutional scheduling compounds these challenges. As one farmer in Southwest Missouri expressed: "Yes, a government agency. They're supposed to help, but they set the times."

Service providers, operating in a field that values punctuality and structured schedules, sometimes interpret these time management differences through a cultural lens. One service provider observed:

> I think culturally, they [Latino farmers] would rather tell you yes to something, and not do it, because they don't want to disappoint you. And so, time management means absolutely nothing to some cultures. —Service Provider, Southwest Missouri

What may appear as cultural difference often reflects adaptive livelihood strategies shaped by limited access to institutional and financial capital (Valdivia et al., 2012). Farmers managing multiple income sources, limited resources, and family responsibilities necessarily prioritize flexibility, while service providers' expectations, shaped by mainstream institutional norms, may not align with these practical realities. Time management thus becomes a space where adaptive livelihood strategies are misread as cultural deficiency.

Theme 4: Communication and Language Barriers Between Latino/a Farmers and Service Providers

Language proficiency and cultural communication styles represent critical dimensions of human capital that shape Latino/a immigrant farmers' access to agricultural resources and services (Valdivia et al., 2012). When newcomers lack English fluency or operate from different communication norms, their ability to build diverse networks, particularly connections to institutions beyond family and friends, remains constrained.

Statistics underscore these challenges. Among recent Latino/a immigrants who arrived within the past five years, approximately one-quarter are proficient in English (Pew Research Center, 2023). As noted above, acculturation along either dimension is associated with a lower likelihood of market entry (Leiva et al., 2025). Beyond language proficiency, cultural communication styles create additional friction. In high-context communication settings, where meaning is conveyed through implicit cues, shared understanding, and relationship-building rather than explicit verbal exchange, indirect communication is preferred, emphasizing social harmony (García-Pabón & Ostrom, 2015). Participants in this study, predominantly from rural communities in Mexico, Guatemala, and El Salvador, where interpersonal trust and face-to-face interaction are central to social and economic life, reflected this pattern. This approach contrasts with the low-context communication style favored by U.S. service providers, who prioritize directness and efficiency. Service providers recognize the systemic nature of these gaps. One provider described the disconnect:

> A lot of the small farmers are doing year-round. None of them are Hispanic. It's a pretty easy thing to do: fill out a form, get a lot more money from the government, it's like a [US]$10,000 deal. There's no way that I am aware of that there is any kind of interface between the Hispanic community. We are always going to have the barrier of language, on both sides. —Service Provider, Central Missouri

Another provider in Southwest Missouri illustrated how personal connections can bridge cultural barriers: "I told him about my background working in Mexico, it's like he blossomed. He opened up to me, and we talked about how we both were familiar with Sonora. So, we were able to sign a loan." Farmers described their own adaptive strategies for navigating these barriers:

> As a Mexican, you don't really use the computer, many of us don't watch TV in English. In the morning, they give estimates on all the animals' worth. If I have to call an American by phone, I won't be able to say anything. Face to face, I can, because if he doesn't under-

> stand, I can use a different method. —Farmer, Southwest Missouri

This reliance on face-to-face communication reflects a communicative habitus shaped in high-context cultural settings, which misaligns with the low-context communication rules governing the U.S. agricultural field. The U.S. agricultural field operates largely through written forms, phone calls, and digital platforms, creating friction for farmers whose prior experiences did not include these modalities. Research confirms that major agricultural services, including USDA programs, are predominantly offered in English, creating significant access barriers for Spanish-speaking farmers (Calo & De Master, 2016; Minkoff-Zern, 2019; Ostrom et al., 2010). In response, USDA released a department-wide language access plan acknowledging that limited English proficiency has historically prevented meaningful access to federal agricultural resources and programs (USDA, 2023), although availability continues to vary across agencies and local offices. Addressing these barriers requires systemic investment in bilingual outreach, culturally responsive programming, and communication strategies that accommodate both linguistic needs and cultural preferences for relationship-based interaction.

Theme 5: Market Entry and Risk Mitigation Challenges for Latino/a Farmers

Latino/a immigrant farmers face substantial challenges with market access, product management, direct selling, and price volatility. Market engagement draws on the full range of capitals that Valdivia et al. (2012) identify, but depends particularly on the accumulated market knowledge, established buyer relationships, and institutional connections that newcomer farmers are still building (Leiva et al., 2025).

Participants from Mexico, Guatemala, and El Salvador described agricultural systems in their home regions characterized by intermediary-dominated transactions, limited access to formal markets, and dependence on informal arrangements, experiences that shaped their expectations and strategies upon entering U.S. agriculture. One farmer described this experience:

> That is what worries us the most, because we came from Latin America, when you have a product there, and you were going to go sell it, there was always an intermediary. We called him the *coyote*. We would sell it to him at the price they wanted because no one would buy it [directly] from you. —Farmer, Central Missouri

These prior experiences shape farmers' habitus, which in turn conditions how they perceive risk, intermediaries, and market participation in U.S. agriculture. Leiva et al. (2025) found that increased investment in agriculture and training significantly enhances the probability of market engagement. However, many farmers lack access to marketing knowledge (Minkoff-Zern, 2019; Ostrom et al., 2010), business expertise, and technical education (Gonzalez & Jeanetta, 2013; Minkoff-Zern & Sloat, 2017). These gaps are compounded when farmers have limited English proficiency and less exposure to formal schooling, which can heighten their reluctance to engage with government agencies and institutional support programs (Minkoff-Zern, 2025). As one farmer in Central Missouri stressed, the need for training and information is acute: "If we had a little bit more information and help with how to enter the market. I think that a lot of people know how to work well. We need small farming trainings …"

Price volatility presents another significant challenge. García-Pabón (2011) notes that Latino/a immigrant farmers' socioeconomic backgrounds influence their risk management approaches, often leading to higher vulnerability due to limited understanding of mitigation strategies for price risks. One farmer described the difficult calculations involved:

> No, I didn't sell because the asking price was too cheap and I wasn't going to just give them away. I had to maintain them all that time and even still, I had to give them away at that same low price. So, since you sell at a high price, you also have to buy at a high price, but you also sell. Even if you buy cheaply, if you sell cheaply, that's how you lose more. —Farmer, Southwest Missouri

Service providers observe these struggles firsthand. One provider shared:

> This man has had his farm for 20 years, and he said, "I've worked a factory job, I've struggled. I have some cows and garden spots. I want to make my farm work for me so I can pay this thing off. I have had it for 20 years and it's not helping me. I'm in the red more than I am making any profit." —Service Provider, Central Missouri

These dynamics illustrate how structural access barriers, not individual capacity, account for many of the market engagement gaps documented in the Latino/a farming literature.

Theme 6: Financial Practices and Livelihood Strategies Among Latino/a Immigrant Farmers

Latino/a immigrant farmers approach financial decisions and livelihood development in ways that often differ from conventional U.S. farming practices. Valdivia et al. (2012) identify financial capital (including income, savings, and access to credit) as a critical component of wealth creation, noting that newcomers' financial strategies are shaped by their prior experiences and available networks. Leiva et al. (2025) demonstrated that combined personal and household income is significantly associated with agricultural sales volume, illustrating how these financing choices enable market participation despite limited access to formal credit.

For many Latino/a farmers, prior experiences with economic instability, currency volatility (Ocampo & Martin, 2003), and financial exclusion (Pérez et al., 2021) inform a preference for cash transactions and caution toward formal banking relationships. These financial dispositions reflect a habitus shaped by economic systems where formal banking was inaccessible, resulting in reliance on embodied financial knowledge rather than institutional financial capital. As one service provider in Southwest Missouri observed, "It's interesting that a lot of businesses owned by Latinos, it's cash stuff. They are not going to any commercial banks and borrowing the money to buy the storefront."

This preference for tangible assets over formal credit shapes distinctive livelihood strategies: purchasing small plots across different locations as funds allow, diversifying revenue through on-farm and off-farm income, and gradually transitioning into formal markets. As one farmer in Southwest Missouri explained, "You buy some acres, like 30, then work those for hours. So those acres generate the income we use to pay for them." Service providers often struggle to understand these operational patterns:

> One family that I have been working with the last couple months, they own 10 acres here, a half mile down, they have 20 acres. Another town over, they have another 25 acres. Typically, our local farmers know that if they want to sign up for a program or have an operation, they really need to keep it together or close enough that they can touch. —Service Provider, Central Missouri

However, reliance on cash transactions creates challenges for accessing government programs. As one service provider explained:

> Cash transactions are hard to track, which means they are hard to prove, which means that you can't qualify. They don't write it down; they don't file a Schedule F [with their annual tax filing]. Cash transactions are more difficult to quantify and prove to apply for government programs. —Service Provider, Central Missouri

Latino/a farmers' smaller scale of operations often disqualifies them from government small farming programs (Leiva et al., 2025). One provider highlighted this mismatch:

> The biggest obstacle that we are running into is that their house and land is a little bit smaller, about 20-25 acres. And a lot of our problems are based on wells, the number one thing they wanted was a well. But it is based on acres served. So, if you come in and you have a 20-acre farm, and we're only going to give you $120 towards a well, that's not going to pay much. —Service Provider, Southwest Missouri

Leiva et al. (2025) found that increased investments in agriculture and training significantly improve the likelihood of market engagement, suggesting that targeted support could accelerate transitions toward profitability. As Valdivia et al. (2012) suggest, institutions serving newcomers should recognize and accommodate these distinct financial strategies to support wealth creation. Effective interventions should include revised eligibility criteria that account for dispersed, small-acreage operations. Such adaptations would better align institutional support with the assets and strategies Latino/a immigrant farmers bring to agriculture.

Theme 7: Cultural Gender Roles Among Latino/a Immigrant Farmers and Service Providers

Gender dynamics within Latino/a immigrant households shape patterns of social capital development and network access. Cultural norms around gender roles, including expectations about who communicates with institutional representatives, can influence which family members build connections with service providers and, consequently, who gains access to agricultural resources and information. While these dynamics do not characterize all Latino/a households, service providers described encounters where traditional gender expectations influenced professional interactions.

Female service providers described encountering barriers rooted in traditional gender expectations. As one provider in Central Missouri reflected:

> I thought about it as a barrier, is being a female, and the Hispanic culture is a little different. I can't go to the men and talk to the men and have them respect what I have to say or maybe even acknowledge what I have to say.

This experience reflects how gendered expectations, which are present across some farming communities but shaped in this context by the habitus of some Latino/a households, can create friction in the U.S. agricultural setting. Male service providers described parallel challenges when attempting to communicate with Latino/a women:

> I have talked to many Hispanic wives, and they say, "My husband isn't here." They won't even hardly pass a message on: "No, you call him." And I'm just trying to tell them of an appointment. And it's cultural, it's a big cultural thing. Husbands don't like that sort of thing. So, there's definitely that demographic that causes issues as well. —Service Provider, Southwest Missouri

Among some participants in this study, these dynamics reflected a gendered habitus shaped by gender socialization in their home regions of Mexico, Guatemala, and El Salvador, structuring who accumulated institutional social capital through service-provider interactions. Males lead and females often assume more subordinate roles adhering to male authority (Kemp & Rasbridge, 2004). Cultural constructs of *machismo* and *marianismo* can prescribe specific roles and behaviors for men and women in some communities (Chong & Baez, 2005). However, gender ideologies within Latino/a communities are not static. Walters and Valenzuela (2020) document evolving perspectives that emphasize respect, fairness, and affection in familial and interpersonal relationships, suggesting shifts toward more progressive norms. Recognizing this diversity is essential; service providers who assume uniformity risk misreading individual households and missing opportunities for engagement.

Gender dynamics thus shape who enters the acculturation interface in the first place. They determine whose institutional social capital accumulates through service-provider interactions and whose access to programs, training, and market information depends on intrahousehold information relay.

Discussion and Conclusion

This research examined how culture and acculturation shape farmers' engagement with service providers and access to available resources. Grounded in Valdivia et al.'s (2012) framework on capital creation and complemented by Bourdieu's (1990) concepts of habitus and field, the analysis shows that Latino/a immigrant farmers draw on human, social, cultural, and economic capital to establish sustainable livelihoods.

Figure 1 synthesizes how the seven themes populate the bidirectional acculturation interface proposed in the Conceptual Framework: farmers arrive carrying dispositions shaped by prior institutional contexts, and service providers carry assumptions rooted in mainstream agricultural norms (Theme 1). The outcomes of their interactions depend on whether these cultural frames align or misalign within the U.S. agricultural field. Trust deficits from prior encounters with corruption and discrimination (Theme 2) make farmers hesitant to engage with formal institutions. Communication barriers (Theme 4) limit network expansion beyond family and friends. Program structures designed for conventional operations fail to recognize the distinctive livelihood strategies these farmers employ (Themes 3, 5, and 6), including incremental land acquisition, cash-based financing, and balancing off-farm employment with weekend farming. Gender dynamics (Theme 7) further shape who enters the interface in the first place. These dynamics interact through the feedback loops depicted in Figure 1: farmers who distrust institutions avoid documentation, which disqualifies them from programs, which reinforces perceptions that programs are "not for us."

The framework identifies two mechanisms operating at the interface. The *misalignment mechanism*, the dominant pattern in our findings, occurs when farmers' and service providers' culturally shaped habitus fail to align, blocking farmers' capacity to convert existing capitals into institutional support. The *alignment mechanism*, visible in moments such as the Sonora loan conversation, occurs when service providers recognize the capitals farmers bring and extend institutional access on that basis. The interface thus produces variable outcomes within the same institutional field depending on which mechanism operates.

Valdivia et al. (2012) found that immigrants who achieve integrated acculturation develop diverse networks that improve access to information and opportunity, while those experiencing exclusion remain in insular networks that limit economic mobility. Our findings align with this pattern: farmers whose social capital remains concentrated in family-based networks due to language barriers or negative context of reception face greater difficulty accessing institutionalized capital in the agricultural setting. Leiva et al. (2025) quantified these dynamics, demonstrating that both Anglo and Spanish acculturation are associated with a lower likelihood of market entry, while Anglo acculturation and negative perceptions of community context are each significantly linked to reductions in agricultural sales.

These findings have direct implications for how institutions (USDA agencies including the Farm Service Agency and Natural Resources Conservation Service, state departments of agriculture, university extension programs, the Farm Credit System, commercial agricultural lenders, and community-based organizations) serve Latino/a immigrant farmers. A first priority is cultural responsiveness. Training that builds cultural competence and cross-cultural communication skills, programming that accommodates relationship-building and flexible scheduling, and bilingual outreach are not peripheral accommodations but core requirements, particularly given that only about one-quarter of recent Latino/a immigrants are proficient in English (Pew Research Center, 2023). A second priority is the design of eligibility criteria. Program requirements built around large-scale, consolidated operations systematically exclude the small-acreage, geographically dispersed farms documented in this study. Revising acreage thresholds and documentation requirements to accommodate incremental land acquisition and dispersed holdings would better align institutional support with farmers' actual livelihood strategies (Leiva et al., 2025; Minkoff-Zern, 2025).

A third priority is financial access. Farmers' preference for cash transactions creates documentation barriers that disqualify them from many programs. Accessible financial products, such as microloans with simplified applications, Spanish-language financial literacy programming, and matching-funds structures aligned with incremental, self-financed land acquisition, would expand institutional access without demanding that farmers abandon strategies that have served them well.

A fourth priority is context of reception. This study found that single dismissive encounters, such as being ignored in a USDA office, reinforced institutional wariness in ways that shaped farmers'

subsequent engagement. Creating welcoming environments through inclusive programming, anti-discrimination training, and network-building opportunities that connect Latino/a farmers to established agricultural institutions addresses the relational foundation on which everything else depends.

Limitations and Future Research

Several limitations warrant consideration. First, the qualitative sample of 32 farmers, while appropriate for in-depth thematic analysis, reflects a specific context; transferability to other settings will depend on the degree of similarity between those contexts and the conditions described in this study. Second, the findings are grounded in a specific participant population (predominantly Mexican, Guatemalan, and Salvadoran immigrant farmers in Missouri) and should not be generalized to all Latino/a farming communities. States with longer-established Latino/a farming populations, such as California, Texas, or Florida, differ not only in agricultural conditions but also in the national origins, migration trajectories, and institutional contexts of their Latino/a farming communities. Third, the cross-sectional design captures a single point in time; farmers' relationships with institutions likely evolve as they accumulate experience and social capital. Fourth, translating qualitative data from Spanish to English introduces interpretive risk, particularly for culturally embedded terms such as *coyote* (intermediary) and *bordo* (water dam) whose connotations resist direct translation. This risk was mitigated by the use of native Spanish-English bilingual translators from the research team and by a collaborative verification process in which vocabulary questions were resolved through consultation among team members and colleagues rather than assumed.

Future research should extend beyond Missouri to validate these findings across diverse agricultural contexts, employ longitudinal designs to track how farmer-institution relationships develop over time, and include larger samples that permit quantitative analysis of factors predicting institutional engagement. Investigating the potential of digital technologies to enhance market accessibility for Latino/a farmers, while accounting for technology access barriers identified in this study, could provide valuable insights for program design.

As Missouri's Latino/a farming population continues to grow, the institutional choices made today will shape whether these farmers become fully integrated contributors to the state's agricultural economy or remain on its margins. The farmers in this study are not waiting for permission: they are buying land incrementally, building operations on evenings and weekends, and drawing on agricultural knowledge developed across generations in their home countries. What they lack is not motivation or agricultural knowledge, but access to institutionalized capital: information channels, program eligibility pathways, and service providers equipped to recognize their cultural and livelihood assets. Bridging these cultural divides requires more than translation. It requires institutions that accommodate farmers' actual operations and recognize the assets Latino/a immigrant farmers bring as contributions to the agricultural field rather than problems to be managed. As the U.S. farming population ages, supporting Latino/a immigrant farmers effectively matters not only for equity but for the practical future of U.S. agriculture.

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Planning for the "new normal": Farmworker support organizations' experiences of climate change impacts and adaptation

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Abstract

Farmworker support organizations (SOs) in central Washington state are experiencing climate change–related impacts. To understand the challenges these organizations are facing, how they observe tree-fruit farmworkers navigating these impacts, and what gaps exist in farmworker support, we carried out a multimethod qualitative case study, interviewing 24 staff from community health clinics and centers, community-based organizations, and research and training organizations. The analysis found that SOs are providing essential support related to climate change, and that need for these services in increasing. Several factors converge to make it challenging for SOs to effectively contribute to long-term, sustainable solutions: limited capacity, staff burnout and, in some cases, the fact that staff do not make the connection between increasing heat and smoke events and climate change. We propose that three principles could strengthen efforts to agree upon and implement long-term climate resilience strategies for the benefit of farmworkers' health and safety and the sus-

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tainability of tree-fruit production: (1) addressing the systemic inequalities that contribute to farmworkers' vulnerability, rather than focusing narrowly on individual preparedness and reducing exposure; (2) bringing together diverse players to propose solutions for protecting workers within the context of farm economic viability, so as to reduce the potential for unintended consequences to the tree-fruit production system; and (3) incorporating adaptive strategies that attend to how climate change impacts people differently, unevenly, and disproportionately.

Keywords
farmworkers, climate change, support organizations, climate adaptation, tree fruit, farmworker health, farmworker safety

Introduction

Increasing temperatures across the globe are leading to more very hot days and greater wildfire activity across the western U.S., increasing the risk of co-occurring heat and smoke (Abatzoglou et al., 2021; Marvel et al., 2023; Rosenthal et al., 2022). Farmworkers who work outdoors are increasingly at risk from climate change–related impacts, with profound potential implications for both worker well-being and food production systems. Recent heat and smoke events have led to revisions or implementation of heat rules and the development of smoke rules for outdoor workers in some U.S. states (e.g., Oregon Occupational Safety and Health [OR OSHA], 2023, 2024; State of Nevada Department of Business and Industry, 2025). The ongoing and anticipated impacts of climate change on conditions for farmworkers are beginning to be researched (e.g. Fenske & Pinkerton, 2021; Marlier et al., 2022; Pagán-Santana et al., 2023), yet little has been documented about implications for the network of governmental and nongovernmental organizations that support them.

Farmworkers of varying backgrounds rely on an extensive but underresourced network of governmental and nongovernmental support organizations (SOs) that provide direct services, and in some cases indirect services such as advocacy. These SOs may or may not be thinking consciously of how their own roles are shifting in the face of climate change. They also have an important view of how farmworkers experience adverse conditions, and whether they need additional support. While SOs have the potential to support adaptation, such social organizations are not always resourced to prioritize adaptations to increasing environmental and socioeconomic risks such as those posed by climate change (Boone et al., 2018; Folke et al., 2005; Gallaher et al., 2013; Pahl-Wostl et al., 2012).

Our work focused on understanding how these roles and issues play out in tree-fruit production systems in central Washington State, U.S., a large, labor-intensive agricultural system in a region already seeing effects on people and production from increasing temperatures and more frequent and pervasive wildfire smoke. Washington accounted for 76% of the nation's apples in 2024, more than 90% of its organic fresh apples, 38% of pears, and 52% of its sweet cherry production (Northwest Horticultural Council [NHC], 2024; U.S. Department of Agriculture, National Agricultural Statistics Service [USDA NASS], 2025). Tree-fruit orchards have fluctuating labor needs and employ both year-round and seasonal laborers, estimated at 68,400 individuals annually in Washington (Gallardo et al., 2024; NHC, 2024). Farmworkers' experiences differ depending on their background, employers, legal and migration status, and many other factors. Labor issues are a highly contested space.

The purpose of this case study is twofold. The first is to improve our understanding of how farm-

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worker SOs are experiencing climate-related impacts and how they observe tree-fruit farmworkers navigating these impacts. The second is to identify gaps in the farmworker social infrastructure that need attention, as a first step toward supporting climate adaptation. This work aims to complement other existing sources of information, including surveys of, and conversations with, farmworkers (Luciano et al., 2025; Parker et al., 2024), and farm employers and managers (Parker et al., 2025; Postma et al., 2025).

Background and Context

Governmental and nongovernmental farmworker SOs play critical roles in providing farmworkers with access to social and health care services, legal counsel, training, and basic needs such as food and educational opportunities (Erwin, 2022a; Kim et al., 2016; Madrigal, 2023; Sbicca, 2020). Some of these diverse organizations focus on service provision, others on advocacy, and some blur these traditional boundaries to provide both (Posada, 2025). They include community health centers, legal services organizations, labor unions and advocacy organizations, community-based organizations, faith-based organizations, and state institutions such as departments of health and agriculture. Many, but certainly not all, of the individuals working within these organizations share similar language, culture, or socioeconomic circumstances with farmworkers and have a long history of engaging in ways that are culturally and linguistically appropriate (Marcom et al., 2020; Olaniran et al., 2017; Thompson, 2021). Some organizations are farmworker-organized (Madrigal, 2023), and many other organizations utilize a participatory approach, though this has been criticized at times for failing to adequately address the structural inequalities and power imbalances that contribute to farmworker challenges (Erwin, 2022b; Thompson, 2021).

Climate-Related Impacts and Projections

Eastern Washington's tree-fruit production region has a temperate, semi-arid climate with hot, dry summers. The number of very hot nights (minimum temperature of 18.3° C/65° F or higher) has generally been higher than long-term averages since 1990, while the number of very hot days (maximum temperature of 35° C/95° F or higher) has been variable, but above average since 2015 (Frankson et al., 2022). Future projections indicate that Yakima, Benton, and Okanogan counties—counties with high numbers of tree-fruit workers—are expected to experience a 35-day increase in the number of days with a heat index greater than 32.2° C (90° F) by mid-century, compared to 1971–2000 averages (Abatzoglou, 2013; Climate Toolbox, 2025). Figure 1 provides relevant projections for Benton County, Washington.

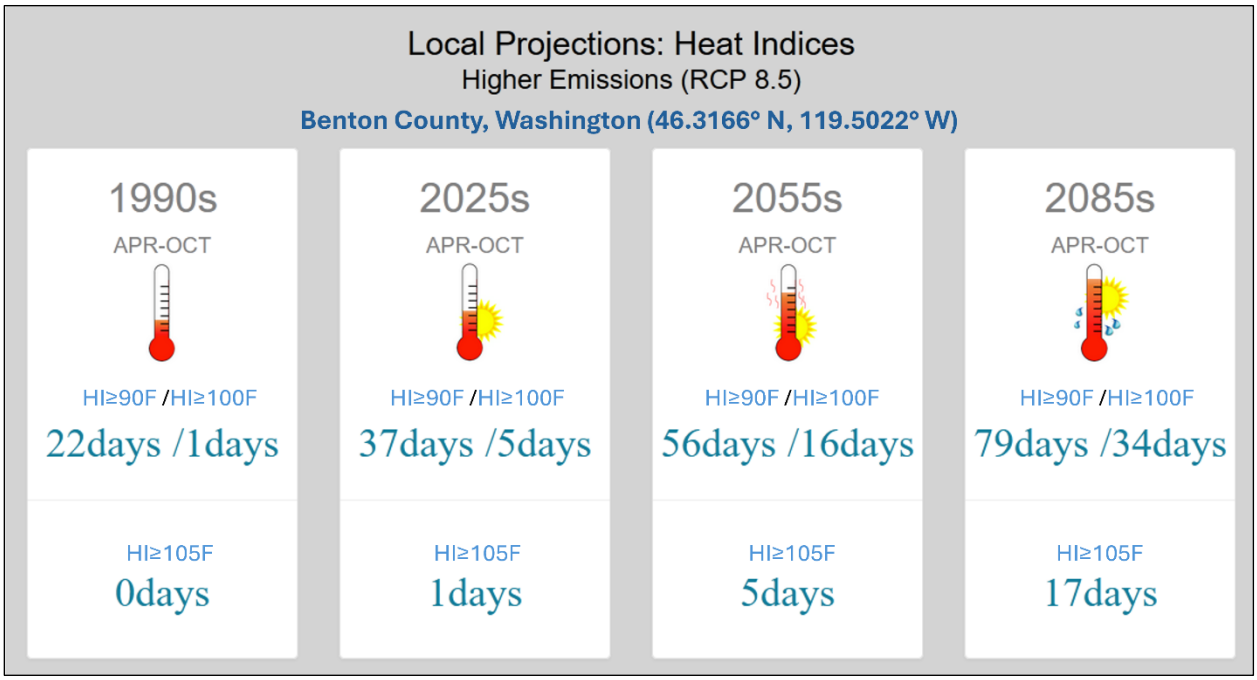
Wildfires have become larger, hotter, and more frequent over the last several decades, due to a suite of factors including climate change (Abatzoglou & Williams, 2016; Halofsky et al., 2020). This trend is expected to continue where fuels are sufficient (Holden et al., 2018; Parks & Abatzoglou, 2020), increasing air pollutants and risks for outdoor workers. There is also evidence that smoke events will increasingly co-occur with heatwaves (e.g., Kalashnikov et al., 2022; Rosenthal et al., 2022), compounding health threats (Ebi et al., 2021; Rahman et al., 2022).

Climatic changes are also likely to impact workers by affecting tree-fruit crop cycles, with accelerated development, earlier crop maturity, and a shorter growth season (Rajagopalan et al., 2018). Weather events in recent years compressed the windows for labor-intensive thinning and harvest, reducing potential worker income. This has likely economic and social implications, including reduced labor demand and layoffs (El Khayat et al., 2022; Fenske & Pinkerton, 2021; Pan et al., 2021).

Frontline Farmworkers and Their Exposure to Heat and Smoke-Related Impacts

Farmworker populations in the U.S. are diverse and changing. An increasing number come temporarily from another country (largely Mexico or Central American countries) through the federal H-2A Temporary Agricultural Workers Program (Gallardo et al., 2024). In Washington State, H-2A workers are the primary labor force in the tree-fruit sector, and usage of the H-2A program increased 513% from 2013 to 2023, from 6,303 to 38,664 workers (Washington State Employment Security

Figure 1. Anticipated Increases in the Number of Very Hot Days in Benton County, Washington, 1990s to 2085s



Source: Figure generated using the Climate Toolbox, 2025.

Department [ESD], 2024). Washington ranked third nationally in 2023 (after California and Florida) in the number of H-2A workers. Other tree-fruit workers in Washington include U.S. citizens, legal residents, and those without legal documentation. The H-2A workers tend to be males in their early 20s to mid-40s, whereas non-H-2A migrant and resident workers include more families, and ages that stretch into the 60s. Undocumented worker numbers are not well defined at the state level, but nationally it is estimated that 44% of farmworkers are not legally authorized to work in the U.S. (Gold et al., 2022).

Farmworkers are disproportionately affected by a changing climate, partly because of the places where they live and work (Frank et al., 2004), and partly due to institutionalized inequality (Heine et al., 2017; Rodman et al., 2016). These disadvantages persist alongside the fact that, in Washington, farmworkers have legal protections around health and safety, working conditions, minimum wage, overtime, collective organizing and bargaining, and workers' compensation (Washington State Department of Labor and Industries [WA L&I], 2018, 2023a, 2023b, 2023c, 2025). There is substantial evidence relating exposure to heat and wildfire smoke to farmworker occupational injuries, including heat-related illness, kidney injury, adverse pregnancy and birth outcomes, and mental health effects (Ebi et al., 2021; Rahman et al., 2022; Spector et al., 2016, 2019). Smoke exposure can also cause respiratory and otolaryngological irritation; chest aches; increased heart rate; and aggravations of underlying asthma, emphysema, and chronic bronchitis (Austin et al., 2021; Riden et al., 2020; Yao et al., 2016). High heat and wildfire smoke tend to occur from July through September, when farmworker numbers are at their highest (Austin et al., 2021).

Management and Policy Changes to Address Heat and Smoke-Related Impacts

In Washington State, recent impacts of heat and smoke on outdoor workers and new information suggesting the occurrence of illnesses below prior policy "trigger temperatures" contributed to increased attention and action, including policy changes, altered schedules to reduce heat exposure

(for fruit as much as for workers), employer and employee education, establishment of cooling centers, air quality monitoring, and better access to protective equipment and health care (Austin et al., 2021; Chicas et al. 2021; Ramos & Schenker, 2021; Riden et al., 2020).

Washington is one of seven U.S. states that have workplace heat stress rules in place, along with California, Colorado, Maryland, Minnesota, Nevada, and Oregon (Natural Resources Defense Council [NRDC], 2025). Only Washington, Oregon, and California have year-round rules pertaining to occupational exposure to wildfire smoke (Yaniz, 2023). In Washington, the updated Outdoor Heat Exposures rules (Washington Administrative Code 296-62-095 through 09560 and 296-307-097 through 09760; WA L&I, 2023a) include requirements for shade, rest, and acclimatization (WA L&I, 2023b, 2023d). At or above 90° F (32.2° C), a 10-minute cool-down period every 2 hours is mandatory, increasing to 15 minutes every hour at 100° F (37.8° C). Washington's smoke rules, effective since January 2024, require employers to prepare a written response plan, train employees, monitor fine particulate matter (PM2.5) conditions and forecasts, establish a two-way communication system, provide protective equipment as air quality thresholds are exceeded, and make provisions for prompt access to medical care if needed (WA L&I, 2024).

Several factors make central Washington a useful location for exploring our study questions, including the increasing heat and smoke exposure and impacts on farmworkers as the climate changes, the management and policy changes being implemented in the state, and the existence of a diverse networks of SOs serving tree-fruit farmworkers in the area.

Applied Research Methods

This study's questions were conceptualized after an extensive literature review and informal interviews with practitioners and include: How do farmworker SOs in central Washington experience and respond to climate-related impacts in the communities they serve? How do SOs describe gaps or unmet needs in climate adaptation for the communities they serve? To shed light on these questions, we carried out a multi-method case study analysis (Brewer & Hunter, 2006; Creswell, 2015; Yin, 2018) focused on farmworker SOs in central Washington. We selected the case of farmworker SOs because (1) SOs may be in a position (or could be enabled, with greater capacity) to support more effective climate adaptation; (2) we are unaware of other work focused specifically on farmworker SOs; and (3) SOs have direct connections with farmworkers and can observe changes in farmworker needs and gaps in service.

Data gathering included semi-structured interviews with SO staff to gain a deeper understanding of these complex issues; meeting notes from a monthly Farmworker Health Coalition composed of SO entities discussing on-the-ground needs and policy change; and three recent farmworker needs assessment reports from central Washington, California, and Oregon, to learn more about how topics of interest were experienced in nearby regions with labor-intensive fruit and vegetable crops. All three data sources were coded and triangulated to identify common themes.

Data Collection

Details of data collection from interviews with SO staff, analysis of meeting notes, and review of assessment reports are discussed below.

Semi-Structured Interviews

We identified interviewees using a combination of purposive and snowball sampling, strategically accessing a specific and difficult to reach population through trust-based referrals. We mitigated potential sampling bias by following a specific set of inclusion criteria to capture a diversity of experiences: years of experience in their professional field, level of staff position within organizational hierarchy, and experience with, or participation in, related policy development. Staff from the three most common categories of SOs were targeted for interviews: community health clinics and centers (clinics), community-based organizations (CBOs), and research and training organizations (RTOs). Inclusion criteria and SO categories were defined with participant observation during the Farmworker Health Coalition meetings, informal interviews with practitioners, and a review of SO web-

sites to capture the greatest diversity of experiences while also ensuring a sampling of respondents who could speak directly to our study questions. The interview guide was designed to uncover SO staffs' views with respect to our study questions, while respecting the way they framed and structured their responses (Marshall & Rossman, 2014). Table 1 provides the interview topics, and some sample questions within each category.

We interviewed 24 staff members from different types of farmworker SOs active in central Washington (fall 2022 through early 2024, halting during the busy growing season). During interviews, we asked about the services provided, breadth and depth of climate-related impacts, and potential pathways toward climate adaptation (Table 1). We did not assess compliance with policy or action thresholds in our interviews, as updates were implemented midway through our study. While all respondents work directly with farmworkers, there are important distinctions between the three categories (Table 2). Clinics and CBOs can speak to worker needs and to service provision impacts. Clinics have a public health focus so can speak to clinically relevant heat and smoke impacts. The CBOs have a stronger focus on advocacy, policy change, and community-based support mechanisms and therefore speak to a broader array of potential impacts. Research and training organizations are generally industry-associated, occupying a social space between management and farmworkers, understanding worker training norms and needs, and offering a unique perspective not otherwise captured.

Interviews concluded once saturation was reached across respondent categories, or when new data no longer provided new insights or themes and the existing patterns were consistently

Table 1. Example Interview Topics and Questions from Interview Guide

Topics	Sample Question
Changing needs	Have you observed changing (i.e., increasing/decreasing) client needs related to environmental threats such as hotter or colder temperatures, wildfire smoke or other climate-related impacts?
Support gaps	Are there service needs that you have observed that neither you nor other organizations can provide?
Organizational capacity	How would increasing frequency and duration of these environmental threats impact your capacity to respond (e.g., extreme heat for more consecutive days)?
Solutions	How have you been able to adjust to meet these changing needs? From your vantage point, what would an ideal response look like?

Table 2. Farmworker Support Organization (SO) Services and Scope and Number of Interviews by Respondent Category

Respondent Category	Services and Scope	# of Respondents
Community Health Clinics and Centers (Clinics)	Provide culturally competent primary and preventative healthcare with an emphasis on occupational health and safety. Staff at Clinics often connect workers to nonmedical social services.	6
Community-based Organizations (CBOs)	Nonprofits that address specific worker community needs by providing or connecting farmworkers to social, legal, and economic support services.	10
Research and/or Training Organizations (RTOs)	State and federal agencies and industry associations that study (tree-fruit) agriculture, labor, and provide occupation-related training to farmworkers.	8
Total		**24**

repeated. Interviews were virtual, recorded and transcribed using the Zoom virtual meeting platform to extend recruitment reach and inclusivity for disparately located SO staff (Archibald et al., 2019; Oliffe et al., 2021), and covered a range of relevant topics (Table 1). The full interview instrument is provided in the Appendix.

Meeting Notes and Farmworker Needs Assessment Reports

To cross-check and enrich interview findings, we gathered data from two years of call meeting notes from a regional farmworker SO coalition and three geographically relevant farmworker assessments. The Farmworker Health Coalition was originally initiated by farmworker-serving organizations across the Pacific Northwest and California to share information and provide support in response to the COVID-19 pandemic. Meetings have continued and aim to center the experiences of both farmworkers and the community health workers who serve them, share challenges, pool resources, and improve coordination to address ongoing and emergent threats to farmworker health and safety (Guild, 2024). These have included smoke, heat, and other impacts of climate change, as well as the lingering effects of COVID-19. Starting in January 2023, we were invited to participate in Coalition meetings. Coalition members included individuals from our three categories of interviewees (Guild, 2024), which helped ensure our analysis was contextualized and relevant to the SO community. Farmworker coalition meeting organizers also allowed us to analyze two years of call meeting notes (20 monthly meetings from January 2022 through December 2023, with four meetings canceled by organizers).

To further understand SO experience of unmet needs for climate adaptation, we searched for publicly available farmworker needs assessment reports from nearby regions with similar labor-intensive fruit and vegetable crops, published between 2015 and 2025. Documents were located using strategic Google search techniques with targeted keywords to find credible, relevant, and high-quality assessment reports (Bowen, 2009). We searched within specific domains (.org, .gov, .edu, .com) and structured queries using relevant word combinations: "climate adaptation" or "climate change" and "farmworker" and "needs assessment." Reports were included if they (1) addressed farmworker populations in the targeted states; (2) were issued by credible sources (e.g., SOs partnered with government or academic institutions); and (3) contained empirical or narrative data on climate-related farmworker health, labor conditions, or social needs. Three documents from central Washington (Rivera & D'Evelyn, 2023), California (Brown et al., 2022), and Oregon (O'Connor et al., 2022)) were selected based on their relevance, recency, and representativeness across the region.

We additionally examined organizational documents—annual reports, presentation materials, websites, other public-facing information—from SOs that participated in interviews to better understand organizational goals, services provided, climate-related impacts to workers, policy recommendations, and other contextual information. The reviewed documents provided additional detail and clarification to interviewees' responses, though they were not explicitly coded and analyzed.

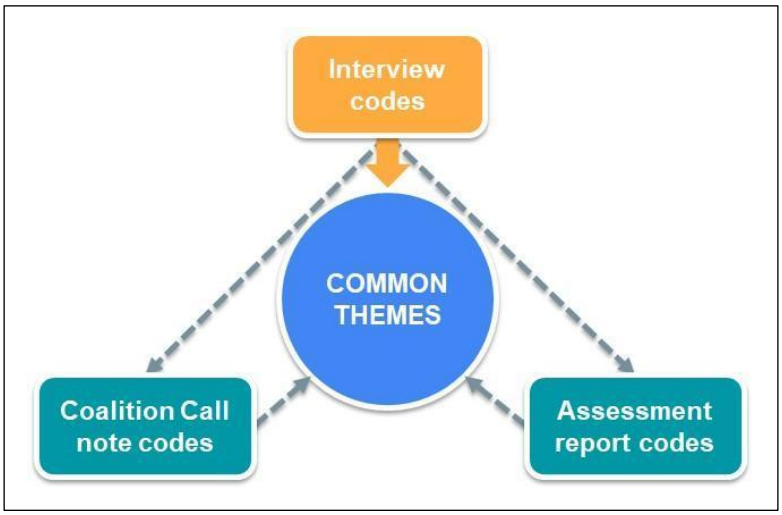
Data Analysis

The first author carried out data analysis, beginning with uploading transcripts from 24 interviews, 20 Coalition call meeting notes, and the three assessments into NVivo qualitative coding software (Lumivero, Denver, CO). Interview analysis took place using a three-step coding process: (1) open coding to condense data into preliminary analytic categories, (2) axial coding to identify key concepts, and (3) selective coding to identify the data that would support conceptual coding categories and final themes (Neuman, 2020). Assessments and call notes were coded deductively using a code book generated from interview questions. Example codes include 'heat impacts,' 'climate-related support gaps,' 'organizational capacity,' 'response needed,' and 'blacklisting,' among others. We coded assessments and call notes to identify similar or divergent instances of farmworker and SO experiences of climate change, to improve the replicability, credibility, validity, and richness of our findings (Neuman, 2020). Analytical memos systematically documented reflections and emergent patterns that formed the basis for themes (Charmaz,

2006). Where codes triangulated across all three data sources, a theme was generated (Figure 2) and is presented as a key finding in the Results section, below. Triangulating interview data with Coalition call meeting and assessment report data provided a richer understanding of the research topic compared to relying on a single data source and increased the validity and credibility of findings (Neuman, 2020; Noble & Heale, 2019; Yin, 2018).

Preliminary themes were shared during two Coalition calls (June 2023 and April 2024) and at the Western Forum on Migrant and Community Health Conference in Seattle, Washington (February 2024) to solicit feedback on the accuracy of findings. We did not receive any feedback contrary to the findings presented but rather reinforcing commentary that the themes captured SO staffs' lived experiences.

Figure 2. Triangulated Analysis with Initial Interview Coding, and Subsequent Confirmation with Coalition Call Notes and Assessment Reports



Results

Four key findings arose that shed light on how farmworker SOs in central Washington are experiencing changing weather- and climate-related impacts, their observations of how frontline farmworkers are navigating climate-related impacts, and their insights into the gaps in farmworker support infrastructure.

Key Finding 1: SO capacity is being stretched as they respond to an increasing number of climate change–related heat and smoke events affecting frontline farmworkers.

Support organization staff emphasized the difficulty of meeting needs relating to increasingly frequent heat and smoke events, especially while they are already stretched thin. They are observing increased demand for SOs to fill emergency response roles during wildfires and have observed spikes in need for personal protective equipment, such as face masks, sometimes beyond their capacity to meet. Heat and smoke have important physical and psychological health dimensions they are trying to mitigate. They also see increased needs for information and regulatory and legal advising related to managing work during heat and smoke. One community health worker shared that:

> When workers are picking, cutting, they're up and down ladders, it's hot, they're doing a lot of cardio and it's humid inside orchards. To wear a mask to protect from the smoke—they're suffocating inside masks. … We have more cases to deal with where workers think they're having [a] heart attack, that they're dying, because they can't breathe inside masks under these conditions, workers have anxiety.

Other climate-related impacts noted less frequently included increased stress among farmworkers due to reduced income resulting from extreme weather impacts on crop productivity, and the compression of harvest during particularly warm seasons. When asked, respondents noted that compressed harvests contribute to the loss of worker income, as harvest represents a time of higher wages from piece-rate pay.

Respondents spoke about how the sheer numbers of workers means that SOs are overwhelmed providing health and safety trainings and basic resources such as medical care, water, face masks, and food. In addition, they described how the increasing numbers of H-2A workers are pro-

foundly impacting SOs' work, as they tend to have higher levels of need and experience greater barriers to engagement and access. Respondents viewed the effect of an increased number of H-2A workers on demand for SO services as compounded by an increased length of stay, as many H-2A workers are staying for six to nine months instead of the once-typical three months. They also described challenges in reaching H-2A workers, given they often live in farm-supplied housing outside of towns, have little control over their time, less access to transportation, and are culturally distinct from local workers.

Respondents indicated that their SOs are finding it harder to meet workers during their shifts to provide resources, given the occurrence of more night shifts and more, smaller farm crews. Increased night shifts are designed to avoid high heat, preserve fruit quality, and extend the harvest window. While this practice can reduce heat-related issues among farmworkers, respondents highlighted additional complications and other negative impacts associated with night shifts: it is harder for workers to see, making the workplace potentially more hazardous; it is also more difficult to obtain childcare.

In addition to these practical challenges, respondents pointed to persistent and systemic inequalities that make it more difficult to meet both climate- and non–climate-related needs of farmworkers, including poverty, living in housing that may increase rather than reduce exposure to high heat, and inconsistent access to physical and mental healthcare. Respondents indicated that heat and smoke illness prevention training is sometimes lacking or inadequate; these trainings are often one of an extensive list of health and safety training topics delivered in a short amount of time. One farmworker trainer that works for the tree-fruit industry highlighted an example from H-2A worker training, sharing that:

> [There is] inconsistency in training [of H-2A workers] because that's up to each company that brings workers. Some companies do an amazing job with them and bring them a week or more prior to work for training. Other companies, on the other hand, bring them just one day before work, and I don't see how one day is enough for all the training they need to receive.

Respondents indicated that collectively, these changes have stretched SOs' capacities to meet workers during their shifts to provide both climate change–related and other resources. The importance of these interacting factors was reflected in the issues the Farmworker Health Coalition identified as needing network support. The top priorities they collaboratively identified in the winter of 2022–23 were, in order of importance: (1) supporting the needs of H-2A workers, including getting them information about local rules and regulations, encouraging them to apply for health insurance, and assessing the impacts of their increasing numbers on local worker populations; (2) circulating information about occupational health, safety, and work availability impacts from year-round climate extremes (e.g., heat stress, wildfire smoke, and cold); (3) inviting grower associations into the conversation about worker health and safety; and (4) addressing chronic illness education.

Key Finding 2: SO staff varied in whether they connected support needs that arise during heat and smoke events with climate change; those who did were more likely to participate in support networks and policy efforts.

When asked if they had experienced an increase in climate change–related needs, some respondents initially indicated that they had not. It was only later in the interview that they connected the increasing heat and smoke service needs they were describing to climate change. For example, at the beginning of an interview, a staff member at a CBO that provides rent and paycheck support to farmworkers during financially difficult times did not connect the increased needs for food and rent support to compressed cherry harvests. Then, after being asked about the potential for increased frequency and duration of environmental threats, they realized the potential link to ongoing climate change and expressed concern that their organization did not have a plan in place for coping with such changes.

Other respondents described their organiza-

tions' responses to heat and smoke events as individual "one-off" emergencies, even while noting the increasing frequency and describing feelings of burnout. A state agency staff member commented during a support call that:

> [It] seems like we're always scrambling at the last minute. Whether a heat wave, wildfires, cold weather. The CBOs are the ones that get hit all the time. They're the ones that continue doing the work, [and are] expected to do more with minimal resources.

Respondents who recognized worker needs as persistent and related to climate change tended to be the same individuals who were engaged in developing resource and information support networks, such as the Coalition calls. They also tended to participate in shaping policy protections at the regional and state levels, including SOs engaged in forward-thinking climate policy work. For example, the Coalition spearheaded a proposal—the Western Smoke and Heat Protection Pact—for strong, consistent, protective rules for heat and wildfire smoke with similar thresholds for action across Washington, Oregon, and California. It recognized that farmworkers may work in multiple states, that they are primarily immigrants, people of color, low-wage, and non-union workers, and that they face disproportionate harms from climate change (Alliance Medical Center et al., 2021).

In discussing the question of how climate hazards have been changing, respondents noted that systemic difficulties make it hard to objectively track whether heat-related illnesses or other climate-related impacts to worker health have been increasing. They noted that the available public records on worker injuries and illness do not indicate the workers' occupations and thus they could not conclusively respond to the question of whether the frequency of climate-related injuries is changing.

Key Finding 3: Multiple factors contribute to farmworkers' vulnerability to heat and smoke events: (1) power differentials and cultural norms contribute to a lack of safe lines of communication through which farmworkers can advocate for their health and safety needs, (2) the development of new state heat and smoke rules did not include sufficient worker participation, and (3) in situations when workplaces are not in compliance, enforcement is inadequate.

All respondents discussed factors that increase farmworkers' vulnerability to heat and smoke events, beyond the physical conditions themselves. Three factors were mentioned repeatedly. First, during every interview, throughout the Coalition call notes and assessments, SO respondents discussed the many factors that prevent farmworkers from advocating for their health and safety needs. They described how workers who communicate safety-related needs are at risk of being blacklisted, or not being invited back to work at the orchard the following year:

> H-2As can't complain or [they] won't get hired next year, they get blacklisted.

The SOs shared that these practices are pervasive because there are few, if any, negative consequences for employers who blacklist. Workers thus tell SOs they do not often express feelings of physical or mental illness, or request water breaks or shade access, for fear of being labeled "weak" or "lazy" by supervisors. Respondents also indicated that they considered cultural norms among the farmworker community, valuing toughness and labeling those who speak about physical or mental illness as "weak," as a contributing factor. A discussion during the October 2023 Coalition call centered on how to support male workers from a culture where individuals who are vulnerable enough to express needs related to physical and mental health may be viewed as less competent, capable, and confident at work. In reference to reporting heat illness symptoms, a worker trainer shared that:

> It's a cultural thing, they don't tend to seek medical attention, they wait too long, this is one thing to get across to them.

Respondents indicated that without permanent immigration status, H-2A workers are even more

reluctant than resident workers to challenge unfair or dangerous working conditions because they fear retaliation, employer termination, and being sent back to their country of origin. The SOs indicated that H-2A workers are more vulnerable to a range of potential workplace hazards and abuses because they are less well informed of their rights than resident workers and are operating under contracts that leave them open to retaliation. The SOs shared that this may make H-2A workers more desirable for employers. One CBO staff member shared that employers

> can lock down H-2A [worker]s, they're more controllable, they have to stay with the grower, can't go shopping for the best price per bin. Why deal with locals who will go to the highest paying grower?

During a Coalition meeting, a state agency staff member said:

> There are many reasons that employers are preferring H-2A workers. They are less informed about their rights as workers, and they are vulnerable since their contracts are tied to a single employer. Because of COVID regulations and wildfire heat and smoke protection [rules] that is why they are preferring H-2A workers.

The second factor contributing to farmworkers' vulnerability that respondents noted was procedural, relating to insufficient opportunity to give meaningful feedback on policy processes that affect farmworkers. Respondents considered the updated and new statewide heat and smoke protections (2023 and 2024, respectively) as important steps forward. However, they described how community input sessions occurred during the regular workday and far from places of employment, identifying these as common procedures when workplace rules are being developed or amended. They also pointed out that H-2A workers are not citizens, do not have "standing," and thus tend not to become involved in rule development. One respondent who has decades of experience advocating for farmworker rights and who grew up working in the agricultural fields of central Washington said:

> I don't think many people took farmworkers into consideration, and when it came to any kind of environmental or climate rulemaking or decisions, or any kind of conversation, you know; so I think that's been one of the more … revealing things around here that how often all these rules and policies are made without any input from farmworkers themselves. You know, it's all industry.

The third contributing factor discussed by respondents relates to insufficient enforcement of either longstanding or new protections for workers. This was widely mentioned, even though respondents generally felt that working conditions have improved over the last few decades. Without improvements in enforcement, SOs doubt that working conditions will continue to improve enough to truly protect workers' health and safety. Respondents discussed two contributing factors. First, noncompliance with previous rules such as access to clean, cool drinking water, adequate shade for breaks, and breaks themselves have not resulted in meaningful penalties, leaving respondents skeptical that new rules will be enforced any better. Second, there is a broad distrust of enforcement entities, encompassing a sense that they are both underfunded and, in the words of one respondent, "on the side of employers." The issue of health and safety rule enforcement arose during 22 out of 24 interviews, 5 out of 20 Coalition calls, and in all 3 farmworker assessments.

Respondents' experience with the state agency charged with developing and enforcing rules and policies that protect workers is that when a worker makes a complaint, agency staff usually communicate with employers before arriving at the worksite to check on a reported rule violation. They described examples of potential violations quickly fixed by the employer before the state Department of Labor and Industries (L&I) arrives, a pattern that has generated widespread distrust. The SOs also report that inadequate staffing and a lack of funding at L&I cause delays in response to reported violations and limit enforcement capacity.

Key Finding 4: More consistent and universal training and the creation of more effective enforcement mechanisms for existing and new policy protections could help improve climate adaptation.

Support organizations emphasized that education about heat and smoke illness prevention practices, rules, and policies should be improved and should be consistent for all employees (H-2As, residents, crew supervisors) and employers (management and owners). They saw this as an important pathway to improving working conditions and reducing climate-related impacts to farmworkers. A participant in the monthly support Coalition calls highlighted a need for:

> more training, in person. Employees and employers need to have the same information, mandate[d] breaks, and protective health and safety. Rules need to be enforced; accountability needs to be enforced.

Several respondents noted that crew supervisors play a key role as they are literally "in the field" ensuring that the rules are implemented, and so they need to be able to recognize the indicators for heat- and smoke-related illness so that they can act when workers need support. A respondent who has experience as a farmworker, trainer, and orchard owner shared that, in their broad experience, most field supervisors and labor managers do not have the needed leadership and soft skills to ensure worker well-being. Another respondent suggested that, if managers were supported to effectively manage delegation, team communication, and conflict resolution, farmworkers under their supervision would be more likely to have better health and safety outcomes. Soft-skill training could also increase supervisor empathy and mitigate blacklisting practices. They also suggested that upper-level managers' and tree-fruit production company leaders' roles are critical, too, as they oversee workflow and worker needs, set the tone for workplace culture around these issues, and ultimately have the power to ensure that protective rules are followed.

Respondents also spoke about the need for adequate implementation and enforcement of not only the new state heat and smoke rules but also prior existing protections such as rest periods, shade, and clean water access. Concerning the new heat rule in Washington, respondents suggested that evaluating preparedness during site inspections and performing true surprise inspections could aid its consistent implementation:

> Rules are great, but the monitoring and implementation has been bumpy. The preparedness should be able to be evaluated during a site inspection.

In addition, individual respondents noted a number of other possible solutions to address particular challenges relating to farmworkers' vulnerability to heat and smoke events (Table 3).

Discussion

Our study adds to the existing literature in several ways, bringing attention to the roles of farmworker SOs in the broader social ecosystem that includes farmworkers, managers, and employers—an ecosystem that modulates how farmworkers experience heat and smoke. Our work demonstrates that increasing exposure to heat and smoke not only negatively affects farmworkers' physical and psychological well-being, but also places additional stress on farmworker SOs and their staff (Key Finding 1). It also uncovers a potential connection between a climate change-informed view of these issues and the likelihood of pursuing systemic changes (Key Finding 2). This study therefore builds on existing work that examines labor issues and solutions as being social and systemic rather than individual problems (Allen, 2016). We also build on existing farmworker-centered scholarship in our region that indicates that farmworkers in the Pacific Northwest have long been navigating heat exposure (Hofmann et al., 2009), and that these risks are increasing (Luciano et al., 2025; Parker et al., 2024). Smoke is also an emerging concern (Parker et al., 2024, 2025; Zuidema et al., 2022). Our study focused on the lived experiences and observations of one set of actors—farmworker SOs—who play an important role in supporting farmworkers within a complex production system. These actors are very aware of the structural power

Table 3. Specific Challenges and Potential Solutions Respondents Mentioned to Contribute to Farmworkers' Preparedness and Resilience to Climate Change

Challenge	Potential Solution
Inadequate or inconsistent training across orchards and among management levels	Convening a coordinated, statewide, state-industry-SO partnership to develop and implement consistent trainings on climate-related impacts for employers, management, and workers alike Leadership training for field supervisors
Inconsistent access by farmworkers to cool indoor spaces	Investing in improvements in cooling of farmworker housing, promoting rest and recovery, which can reduce risk while minimizing impacts to productivity
Inconsistent farmworker access to health and other services	Developing and deploying mobile clinics to improve healthcare access for workers and reach more farmworkers with educational and social resources
Insufficient data to fully evaluate climate-related impacts to farmworkers	Collecting data on heat-related illnesses or other climate-related impacts to farmworker health and cataloguing worker's occupation in the collection of clinical data on work-related injuries and illness
Inadequate enforcement of health and safety including heat and smoke rules	Implementing randomized and unannounced screening of orchards to document health and safety practices and working conditions

differentials and cultural norms that make it difficult for farmworkers to advocate for their health and safety. The SOs also spoke about insufficient farmworker input in the development of rules meant to protect them, and inadequate enforcement in situations where workplace health and safety rules are not being followed (Key Finding 3). In this regard, our findings are broadly consistent with other studies in the western U.S. and elsewhere that have pointed to the power structures that contribute to farmworkers' vulnerability to weather hazards (Courville et al., 2016; Parker et al., 2024; Posada, 2025).

Climate-related risks are intrinsic to the outdoor jobs that farmworkers perform. However, our findings highlight how workers' vulnerabilities are not only a function of their exposure, but also of their sensitivity to impacts and their limited adaptive capacity (Dawson et al., 2011; Füssel & Klein, 2006). Increased sensitivities result from several factors that respondents discussed: the physical demands of their jobs, living in housing that may increase exposure to high heat, poverty and lack of access to healthcare that can increase the risk of pre-existing medical conditions, and in some cases, a lack of acclimation prior to working in the heat. Adaptive capacity is limited by the power dynamics at play, including farmworkers' relative status in the workplace, blacklisting practices, and inadequate compliance with workplace protection rules (Key Finding 3; Rodman et al., 2016; Wadsworth et al., 2022). The differences in effects on different types of workers suggest that flexible, diverse efforts, rather than one-size-fits-all solutions, are needed to address the factors that increase workers' vulnerability to climate or limit their adaptive capacity. These results also suggest that solutions should include a focus on climate justice (Newell et al., 2021; Sultana, 2022), including procedural justice so that farmworkers can meaningfully participate in policy processes that impact their livelihoods and well-being (Holland, 2017; Parker et al., 2024; Ryder, 2018; Zoodsma et al., 2022).

One notable finding was that many individuals working at SOs have not yet linked the increases in heat and smoke incidence with ongoing climate change (Key Finding 2). Heat and smoke events are still being treated as one-off emergencies, and SOs are experiencing burnout from more frequent and severe climate-related needs. This may be inhibiting efforts to build the long-term capacity needed to cope as conditions change. Whether it is through increased investment in SOs or also through investments in other entities, there is a

need to increase the adaptive capacity of farmworker support entities, who are a key element of the food production system.

Another notable theme across our key findings was that vulnerabilities and needs are different for different types of farmworkers (Key Finding 1; Key Finding 3). In particular, the increasing use of H-2A workers across the Washington tree-fruit industry (and likely in other agricultural sectors and areas as well) has had a large impact on the work of farmworker SOs. These workers have a distinct legal status as noncitizens who are formally recognized (as distinguished from U.S. citizens or farmworkers who are undocumented). Their schedules, on-farm living quarters, lack of knowledge about their rights, and their fear of being blacklisted all make them a more challenging population for SOs to reach.

Farmworker SOs play diverse and important roles across the U.S. (Kim et al., 2016; Madrigal, 2023; Sbicca, 2020). While our findings relate to farmworker SOs in central Washington and cannot be generalized broadly, they highlight the need to further explore these issues in other labor-intensive areas of U.S. agriculture, with both likely areas of congruent experience and regional differences due to climate, policy, culture, and other contextual factors. The specific dynamics depend on the baseline conditions and the levels of heat, humidity, and fire experienced in each region (Bolster et al., 2023; Burke et al., 2021). Changes in climate are being felt across the U.S., with increasing incidence of wildfire across the western U.S. and wildfire smoke events even beyond. Although Washington's policy context is more similar to Oregon and California, our findings related to nonregulatory approaches are likely applicable in other areas of the U.S. as well.

Given the limited existing research on SOs' responses under a changing climate, more investigation is needed. In our study area of central Washington, next steps include engaging with a wider range of actors in this complex human-agricultural ecosystem to support the identification and implementation of a range of solutions. Although limited to one geographic region, our study provides an example of the role SOs can and do play in highlighting the experiences of those not adequately supported by the rules and policies meant to protect them. Respondents pointed to the need for more robust enforcement to accompany rulemaking, and consistent training on these rules for farmworkers, managers, and employers (Key Finding 4). These suggestions point strongly to the need for (1) systemic approaches rather than reliance solely on individual action; and (2) a collaborative, comprehensive approach to address climate change impacts on the whole production system, including farmworkers, managers, employers, and the production system itself. Respondents also provided a wide range of other potential strategies to ameliorate specific challenges (Table 3). Other challenges noted by our respondents could be tackled with specific research, information, or tools (Table 4).

Such solutions need to be evaluated and designed in the context of the whole production system. For example, Tigchelaar et al. (2020) showed that increasing rest time or providing cli-

Table 4. Particular Challenges that Contribute to Farmworkers' Vulnerability that Could Be Improved Through Research, Information, and Tools

Challenge	Potential Solution
Inconsistent access to, and use of, accurate data to inform implementation of heat and smoke protections	• Increasing the number of local on-farm weather stations with air quality instruments • Developing a text alert system for high temperature and degraded air quality (similar to Amber Alerts)
Inadequate engagement of farmworkers and others in the tree-fruit industry during rule making	• Expanding the locations and times of public meetings to improve accessibility to farmworkers, growers and others with interests in the process • Establishing processes and funding for CBOs to represent the interests of workers without such access, at the workers' request

mate-controlled recovery areas could effectively eliminate risk even under future projected conditions, but could have strong negative effects on farm productivity, farmworker earnings, and labor costs. For an industry with slim or even negative production margins (Gallardo et al., 2025a, 2025b, 2025c), such additional costs could lead to unprofitable production environments and loss of family farms, consolidation of production, and other changes with unintended consequences to farmworkers' livelihoods. Industry leaders have said that labor costs have grown even more quickly than other costs, rising from an estimated 37% of the growers' returns for a bin of apples in 2013 to 70% in 2022 (Johnson & Prengaman, 2024). These increases threaten growers' ability to withstand market fluctuations, with labor representing an estimated 99% of returns in 2023 as apple prices dropped amid market fluctuations.

Given this unprecedented increase in labor costs, the most likely pathway to successful climate adaptation is one that is inclusive of both farmworkers' health and safety needs and of growers' economic viability, even if this may add challenging dynamics. While such "big tent" approaches can constrain the approaches used, for example, to avoid overly political stances, these efforts also provide new opportunities and have the potential to expand spaces for meaningfully advancing equity (Erwin, 2022b; Weiler et al., 2016). The Washington tree-fruit industry has already collaborated in this way in the area of pesticide education. In partnership with state agencies and university Extension services, the industry has made significant investments in worker health and safety training (including in Spanish) over the past few decades, achieving substantial reductions in pesticide exposure. A similar model is worth exploring to address heat and smoke exposure.

Study Limitations

Our case study focused on the experience of SOs, one type of entity within a complex system. It therefore does not comprehensively represent the full spectrum of perspectives of other actors in the tree-fruit production system. On the one hand, individuals working in SOs hear about the experiences of many different types of farmworkers and are often embedded in farmworker communities themselves; on the other hand, given their role of filling gaps in support, SOs likely represent most closely the view of farmworkers in need of that support, although the full spectrum of farmworker perspectives is likely broader. Further efforts exploring and comparing perspectives are therefore needed to fully understand the challenges and develop solutions.

In addition, this multimethod case study focused on farmworker SOs in central Washington and is not generalizable. Though it is possible, maybe even likely, that some of our key findings are true and relevant in other labor-intensive agricultural regions seeing similar climate trends, our study does not provide sufficient causal understanding of these factors to infer where they might have similar or different influence. Finally, this study does not isolate the climate change–related impacts to farmworkers from other factors that affect them. For instance, Washington State rolled out the updated heat and new smoke protection rules at roughly the same time as new agricultural worker overtime rules (WA L&I, 2025). This led to two different sets of rules influencing the system at the same time, effectively providing unplanned incentives for workers to ignore the health impacts as they tried to reduce the loss of income resulting from employers' responses to those new rules. As these rules fully come into effect, explicit evaluation of how they interact with climate change–related impacts will be needed.

Conclusion

Our aims were to improve understanding of how farmworker SOs are experiencing climate change–related impacts and to identify gaps in the farmworker social infrastructure that need attention, as a first step towards supporting strategies for more equitable climate adaptation. Our focus on SOs in central Washington allowed us to highlight underrepresented experiences in climate change adaptation dialogues and connect these perspectives into ongoing efforts in climate adaptation in tree-fruit production systems.

Based on the integration of this study's findings with the existing understanding of systemwide climate change impacts, we conclude that at least

three elements are needed to design and implement effective climate adaptation strategies. First, it is necessary to address the systemic inequalities that contribute to farmworkers' vulnerability, rather than focusing narrowly on individual preparedness and reducing exposure. Second, diverse players need to come together to propose solutions for protecting workers in the context of farm economic viability, in order to reduce the potential for unintended consequences to the tree-fruit production system as a whole; otherwise, those consequences, in turn, could undermine the sustainability of the solutions. Lastly, any adaptive strategies should attend to how climate change impacts people differently, unevenly, and disproportionately. These three elements are not solutions in and of themselves, but rather principles that would underlie efforts to agree on and implement sustainable solutions for the benefit of farmworkers' health and safety and the sustainability of tree-fruit production under a changing climate.

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Appendix. Interview Guide

Introductory Remarks: Thanks again for agreeing to the interview with me. I work with the Center for Sustaining Agriculture and Natural Resources, a research and education center of Washington State University. The purpose of this study is to identify tree fruit farm worker support services and agencies and assess their needs related to anticipated climate change impacts in central Washington.

We're interested in knowing more about the entities that provide support, what future needs are projected, and what questions you have relating to projected climate impacts on farm workers. In particular, we're interested in assessing if there is a need for collaboration, research and information relating to the increasing likelihood of drought, high heat or frost events, wetter springs and other climate-related environmental threats. We are also interested in exploring what information and resources might help you support workers, that would be more applicable considering changing environmental conditions in the future.

This study has been certified as Exempt by the WSU Human Research Protection Program. For questions about the rights of participants, you may contact the office: irb@wsu.edu. I ask all interviewees the same questions. Your name and responses will not be identified as pertaining specifically to you in anything I write to summarize interview findings. I'm asking to record the interview for internal reference purposes and to ensure I accurately capture your responses. Recordings will be kept on a password protected drive. If recording makes you uncomfortable, I'm happy to just take notes. Are you ok with being recorded?

If there is any question you do not feel comfortable answering, please just let me know and we'll move on to another topic.

Interview Questions

1. I understand that (organization/agency name) provides _____ services to tree fruit farm workers and their families. Are there other environmental health-related services that you offer?
    a. In what format do you provide these services? (I.e., one-on-one consultations, workshops, individual financial support, popular and/or social media?)
    b. Which are your most utilized services?
    c. Are there times of the year when your services are more utilized? For example, do you have a "busy season" and what are the most requested services during these times?
    d. Are there service needs that you have observed that neither you nor other organizations can provide?
2. How would you describe the demographics of your clientele?
    a. Age, sex, race/ethnicity, country of origin, work permit: H2A, seasonal, resident, undocumented or others.
3. Have you observed changing (I.e., increasing/decreasing) client needs related to environmental threats such as hotter or colder temperatures, wildfire smoke or other climate-related impacts? If so, how would you characterize these needs?
    a. How have you been able to adjust to meet these changing needs?
    b. If you've been challenged to meet these changing needs, what would you need to do so? From your vantage point, what would an ideal response look like?
4. We're curious about the potential changes in timing for worker needs since farm labor needs may be shifting in response to climatic changes. For example, increasing temperatures can lead to crops developing more quickly, which may mean a compressed amount of time for harvest and a shorter overall harvest season which may impact paychecks.
    a. Have you noticed any changes to the timing or the types of services needed related to changing environmental conditions?
    b. Probe: In addition to heat-driven changes, are there other timing and service changes related to environmental changes?

5. How would increasing frequency and duration of these environmental threats impact your capacity to respond (I.e., extreme heat for more consecutive days)?
    a. Is there a threshold where current responses would need to be adapted?
    b. Are there particular services that you're worried about being able to provide in the future?
    c. Are there gaps you see in training resources that prevent these threats from being adequately addressed?
6. Does your organization currently utilize research-based information in your programs? If so, how?
    a. From where do you usually get your researched information? (I.e., the University Extension service, agencies, other)
    b. What research or information needs, if any, does your organization have related to environmental threats such as heat, frost, and drought?

If more information is needed on climate-related topics, continue to question 7. If not, jump to question 8:

7. If there were an opportunity for you to access up-to-date and regionally specific information through research or educational programs on climate-related topics, how would you prefer to engage?
    a. What type of format (education, training, connections to research teams, connections to existing resources) would be most useful for you to serve your clients? Are you or have you been involved with climate adaptation or resiliency planning or projects? If so, which project and what is/was your role?
8. Are you or have you been involved with climate adaptation or resiliency planning or projects? If so, which project and what is/was your role?
    a. Can you tell me more about the process and who is/was involved?
    b. How, if at all, did the outcomes change (or do you expect to change) the services you provide to farm workers?
9. Do you have any questions for me?
10. If I have any further questions or need clarification of anything you said, would it be all right if I contacted you again?

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Assessment of needs for produce safety educational resources for non–English-speaking growers in the Midwest

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Abstract

Refugee growers possess diverse agricultural knowledge, but they often face barriers to complying with U.S. produce safety practices due to language limitations and unfamiliarity with Food Safety Modernization Act standards. This study conducted a needs assessment using focus group interviews with advisory board members (n = 6) and refugee growers (n = 10) in Iowa and Kansas

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to evaluate produce safety knowledge and identify educational gaps. The interviews with advisory board members aimed to identify refugee populations, crop types, and training needs. The interviews with growers' focus groups explored knowledge gaps regarding worker health and hygiene, biological soil amendments, and agricultural water safety. The interview transcripts were analyzed using constant comparative analysis. The findings revealed that refugee growers spoke various languages, including Swahili, Kirundi, Nepali, Burmese, Chin, and French. While refugee growers possessed basic knowledge of hygiene and food safety, they lacked understanding in key areas such as sources of contamination, visitor protocols, biological soil amendments, and water testing. We found that language barriers, limited access to training, and cultural differences further hinder effective produce safety compliance. Based on these findings, developing culturally relevant and linguistically tailored educational materials such as short-format, multilingual videos, and posters that reflect growers' traditions and experiences was recommended. Making these resources accessible via platforms like WhatsApp and YouTube can enhance produce safety practices and support compliance with the Food Safety Modernization Act. This research highlights the importance of accessible training to promote produce safety, regulatory compliance, and sustainable agricultural practices among refugee growers.

Keywords
produce safety, refugee growers, needs assessment, educational resources

Introduction

According to World Health Organization (WHO) research, foodborne outbreaks affect approximately 600 million people annually worldwide, resulting in an estimated 420,000 deaths (WHO, 2024). Poor food safety management practices at fresh produce farms have frequently been identified as a significant source of contamination during the investigation of various foodborne outbreaks. In the U.S., one of the deadliest outbreaks was caused by cantaloupes contaminated with *Listeria monocytogenes* consumed across 28 states, leading to the disease Listeriosis, resulting in 33 deaths and a miscarriage (Centers for Disease Control and Prevention [CDC], 2012). This deadly event was traced back to a farm in Colorado, which led to the recall of 300,000 cantaloupes (McCollum et al., 2013). Furthermore, 15 outbreaks of *Escherichia coli* infection occurred between 2010 and 2017 that were associated with vegetable row crops such as romaine lettuce, spinach, and iceberg lettuce. These outbreaks resulted in 299 illnesses and two known deaths (Carstens et al., 2019). An outbreak of 69 infections and 22 hospitalizations caused by *Salmonella* was recently traced to a cucumber grown in Florida (CDC, 2025). The number of reported outbreaks related to the "fresh produce" food category has rapidly increased over the last few decades. Foodborne illness investigations from 1998 to 2008 identified six plant categories as the probable cause of 46% of reported illnesses, which included fruits, nuts, , mushrooms, leafy vegetables, root vegetables, sprout vegetables, and vine stalk vegetables (Painter et al., 2013).

Although substantial improvements have been made in produce safety education, including the establishment of the Produce Safety Alliance (PSA) through a partnership between Cornell University, the U.S. Food and Drug Administration (FDA), and the U.S. Department of Agriculture (USDA) (Produce Safety Alliance, 2019), not every grower community gets equal access to the resources. Most of the current training is tailored toward large-scale farm enterprises and for the English-speaking grower audience. However, some resources have been developed recently for immigrant farmworkers, mainly Hispanic farm workers who are usually trained to perform specific tasks under the guidance of farm managers who oversee food safety (Rajagopal, 2012, 2013). Nevertheless, many refugee and resettled immigrant growers who run small-scale urban farm plots, which are communal, have different farming operations and responsibilities compared to the other immigrant farmworkers in large-scale farms or the produce industry (Nguyen, 2020). These are not employees but independent operators who do all the farming activities themselves, including soil preparation, harvest, postharvest handling, and, in many cases, do this all without regulatory oversight. Many inde-

pendent operators and growers do not speak Spanish; instead, they use languages such as Swahili, Karen, Somali, Nepali, Chin, Burmese, Falam, and others, resulting in a shortage of accessible produce safety resources (Jarman, 2021).

Immigrants and refugees form a large part of the workforce in the agricultural industry, accounting for nearly 70% of all workers (Pokhrel, 2025). Despite the helpful development of Spanish-language resources, there is still a significant gap for non–Spanish-speaking, low-literacy refugee growers whose products are becoming part of local food systems through farmers markets and community supported agriculture. Although small-scale farms produce lower volumes than commercial operations, their produce is distributed directly to consumers, often without the involvement of intermediaries. This means that any contamination can reach vulnerable populations quickly. Moreover, some of these farms often operate with limited infrastructure, such as wash stations, cold storage, or record-keeping systems, which can increase food safety risks if best practices are not implemented (Parker, Schlegel et al., 2016). Without linguistically, culturally, and educationally relevant materials, these growers cannot adopt the best produce safety practices that ensure microbial safety of their fresh produce crops. It has been identified in the literature that the lack of food safety knowledge and educational resources are a significant barrier to compliance with produce safety practices among growers (Chen, Ellett et al., 2021). Education is crucial in mitigating these risks by equipping growers and farm workers with the knowledge and practices necessary to minimize contamination. However, barriers to effective education persist, particularly among non–English-speaking and low-literacy populations, who may struggle to access or comprehend traditional food safety training materials (Fox, 2020; Parker, Wilson, LeJeune, & Doohan, 2012). These challenges are further compounded by refugee growers, who often face unique cultural and linguistic barriers that hinder their ability to understand, trust, and adopt recommended food safety practices (Aning, 2023). Therefore, addressing these challenges through culturally and linguistically tailored training can foster greater trust and improve the adoption of the practices.

Since the resettlement of refugee groups in the U.S., particularly those from Myanmar, Nepal, and the Democratic Republic of Congo, many of these immigrants have engaged in urban small-scale agriculture at an increasing rate. These individuals often participate in production on their own or on shared plots provided by nonprofit organizations or city agencies (International Rescue Committee, 2021). Unlike hired farm workers who perform specific tasks under close supervision, refugee growers manage their plots independently, carrying out activities such as soil preparation, planting, watering, harvesting, processing, and marketing, often without formal agricultural training (Goralnik et al., 2023; International Rescue Committee, 2021). Non–English-speaking immigrants with refugee backgrounds also make up a substantial portion of the Midwest U.S. workforce and are engaged in a wide range of activities within fresh-produce systems. However, growers from diverse backgrounds face multiple barriers, including language differences, cultural variations, and limited food safety literacy. In Kansas and Missouri, refugee resettlement has been supported by social service institutions and agricultural programs such as Global Greens and New Roots for Refugees programs (Fetahovic, 2020). These initiatives are operated by Lutheran Services in Iowa (LSI) and Cultivate KC, respectively, both of which play central roles in providing refugees with access to small production plots, shared infrastructure such as greenhouses, wash stations, and coolers, as well as linguistically accessible training and business development support. Together, they help refugees reconnect with agriculture, build market-oriented production skills, and develop direct market outlets, including farmers markets, community supported agriculture (CSA) programs, and wholesale channels supporting their transition from subsistence gardening to independent, culturally relevant farm enterprises. (Fetahovic, 2020; Nguyen, 2020). These growers sell directly to consumers in local markets, where produce is often consumed raw; thus, their understanding of safe handling practices is crucial.

One of the primary barriers to food safety education is the overwhelming amount of information presented in formats that are not accessible to all

growers (Bianco et al., 2016; Neal et al., 2011). Many educational programs are designed for English-speaking audiences and heavily rely on written materials, which may not be effective for individuals with limited literacy or unfamiliarity with the concepts (Arena & Wheaton, 2021; Dunlap, 2016; Fetahovic, 2020). This is particularly problematic for non–English-speaking growers, who may lack proficiency in English and come from countries with agricultural practices and food safety regulations that differ significantly from those in the U.S. (Nabwiire et al., 2021). To address these challenges, education programs need to be tailored to the specific needs of these populations by incorporating more visually based training and materials in their native languages. Videos, images, and hands-on demonstrations can be more effective than text-heavy manuals, providing clearer, more actionable guidance that transcends language barriers (Li, 2015; Rajagopal, 2012, 2013; Rajagopal et al., 2019). By addressing these barriers and customizing education to the unique needs of diverse grower populations, food safety training can become more inclusive and effective, ultimately reducing the risk of contamination in the fresh produce supply chain.

Hence, it is essential to have needs assessments that reflect practitioners' realities, preferences, and resource availability so that curriculum organizers can adjust the educational content to fit the target population better (Archila-Godínez et al., 2022). The objective of this research was to conduct a needs assessment to identify the gaps in produce safety knowledge and practices among non–English-speaking refugee growers in Kansas and Iowa. The research identified gaps in produce safety knowledge and practices through focus groups, which helped understand these gaps in the context of the growers' operations. The results of this paper will directly guide the creation of visually appealing and multilingual education tools, including posters and video materials that will enhance the safety practices of the produce in this underserved population.

Methodology

Previous research among underrepresented refugee growers revealed different key knowledge gaps among growers from Iowa and Kansas (Fetahovic, 2020; Nguyen, 2020). Needs assessments were employed to reconfirm and identify unique produce safety knowledge gaps. The needs assessment consisted of two focus group interviews that included the participation of advisory board members and refugee growers. The study was deemed exempt by the university's institutional review board (IRB ID no. 24-381).

Selection of Advisory Board Members

Advisory board members ($n = 6$) were purposively selected to represent key stakeholders supporting refugee growers. Selection criteria included: (a) ability to speak the growers' native language; (b) expertise in agriculture, social service, and/or refugee grower support; and (c) being 18 years or older. Members were recruited from Lutheran Services of Iowa (LSI), Cultivate Kansas City (KC), and Catholic Charities of Northeast Kansas. The advisory board comprised two representatives from LSI, two from Cultivate KC, one from Catholic Charities, and a Swahili-speaking student from Iowa State University. This purposive recruitment ensured inclusion of members with diverse perspectives and direct engagement with refugee growers, strengthening the representativeness and relevance of the advisory input.

Advisory Board Members Focus Group Interview Study Design

Focus group questions ($n = 10$) were adapted from Marine et al. (2016) and designed to capture advisory board members' knowledge of the refugee populations they serve, the types of crops cultivated, marketing channels, produce safety needs, and dissemination strategies. Questions were reviewed and refined by four food safety experts and a program evaluator from Iowa State University, Kansas State University, and Louisiana State University, with attention to cultural and contextual appropriateness for the refugee grower population.

Two virtual focus group sessions were conducted using Microsoft Teams in May 2023. Each session was moderated by the program evaluator and lasted 60–90 minutes. The moderator posed questions, guided discussion, and took detailed notes, while a co-moderator ensured thorough documentation of participants' engagement and inter-

actions. The online format enabled participation across geographic locations and accommodated busy schedules.

Data Analysis of Advisory Board Interviews

The program evaluator expanded the session notes by transforming brief notes into detailed narratives while ensuring participant confidentiality. The responses were reviewed multiple times for accuracy by the program evaluator. Two trained researchers performed coding independently. Data were coded using thematic analysis in Microsoft Excel as adapted by Pichayapinyo et al. (2024). Themes were refined through discussion until consensus was reached. These steps ensured transparency, reliability, and reproducibility of the analytical process.

Refugee Growers Interview Design

The advisory board focus group data and prior LSI research (Nguyen, 2020) informed the development of a 10-question interview guide for refugee growers. The interview guide covered growers' characteristics (farm size, crops cultivated, prior produce safety training) and three modules of the Produce Safety Alliance grower training: worker health and hygiene, biological soil amendments, and agricultural water. This focus ensured alignment with high-risk contamination sectors identified in prior research (Olaimat & Holley, 2012; Soon & Baines, 2012). A four-person food safety expert panel, one program evaluator, and two community navigators reviewed the interview guide for clarity, relevance, cultural appropriateness, and ease of translation. The interview guide was revised based on their recommendations to ensure face and content validity.

Selection of Refugee Growers for Focus Group Interviews

A recruitment email was sent to the content development specialist at LSI and to the farm manager at Cultivate KC. Both organizations are nonprofit organizations that provide farm training support focused on refugees and maintain direct engagement with refugee growers, making them suitable connectors for recruitment. Growers were recruited using convenience sampling and had to be 18 years or older and designated as refugee produce growers affiliated with these programs. This approach ensured participants had sufficient experience with agricultural practices and engagement with the organization of interest.

Refugee Growers Interview Protocol

Interviews were conducted with 10 growers (five from Cultivate KC and five from LSI) in January and February 2024. This sample, representing about one-fifth of the total grower population (≈50), was sufficient for capturing diverse perspectives, and interviews reached thematic saturation with consistent and overlapping responses. A moderator, co-moderator, and translator facilitated each session. To enhance communication and comfort, growers were grouped by language (Kirundi, Swahili, Burmese, and Nepali), with translation provided throughout to ensure clarity and ease of discussion. Interviews lasted between 30 and 60 minutes and were audio-recorded with participants' permission using a portable handheld digital recorder. The moderator introduced the research, asked the interview questions, and followed up with probe questions when necessary. At the same time, the co-moderator took notes on responses, participants' ability to engage with questions, and the overall interview atmosphere. Growers were compensated for their time.

Data Analysis of Refugee Growers' Interviews

Audio recordings were transcribed verbatim by the moderator and compared to the co-moderator's field notes to ensure accuracy. Data analysis followed thematic analysis, where open coding was applied to identify key concepts and patterns, as adapted by Pichayapinyo et al. (2024). Microsoft Excel was used to organize and categorize data. Two independent researchers coded the transcripts separately, then met to merge their findings and reach consensus on themes. Trustworthiness was ensured through triangulation, peer debriefing, and detailed documentation of procedures. Credibility, transferability, dependability, and confirmability were addressed by describing research context, participant characteristics, data collection, and analysis steps, ensuring the study's rigor and reproducibility.

Results and Discussion

This section presents the findings from the focus group interviews and discusses the characteristics, farming practices, and food safety communication needs of refugee growers. The results provide insight into the cultural and agricultural diversity of refugee growers and their integration into local food systems.

Refugee Growers' Characteristics from Advisory Board Members

Six advisory board members participated in the focus group interview conducted on Zoom. The information on refugee growers is presented in Table 1. Refugee growers speak various languages, including Swahili, Kirundi, Nepali, Chin, French, and Burmese, and originate from a variety of countries, including Cameroon, Burundi, Ethiopia, Uganda, Burma, and Nepal. These growers cultivate a wide range of crops. The African growers' crops include African eggplant, African corn, roselle, watermelons, mustard greens, and long beans. The Asian growers' crops include Thai chilis, loofa gourd, amaranth greens, and kohlrabi. These findings support previous research by Pivarnik et al. (2018), who indicated that many small-scale produce growers engage in diverse crop production. Many of the crops they grow are staple crops in their home countries. Similarly, Jarman (2021) found that cultural background plays a significant role in determining the crops cultivated by refugee growers. In addition to these culturally significant crops, refugee growers cultivate crops widely consumed in America, including tomatoes, broccoli, lettuce, potatoes, onions, and garlic. This crop diversity illustrates both cultural preservation and adaptive integration into local agricultural systems.

The growers sell their produce through various market channels, as highlighted in Table 1. This diverse marketing approach enables them to reach a broader customer base. The primary marketing channels used by refugee growers align with findings from previous research, which indicate that most small-scale produce growers primarily sell through farmers markets, direct sales, and CSA programs (Chen et al., 2022; Fetahovic, 2020). These channels respond to growing consumer demand for local produce, but as reported by Harrison et al. (2013), farmers markets can present measurable food safety risks when foundational practices are not followed consistently. Observational and microbial analyses have identified gaps in sanitation, temperature control, and access to hand-washing facilities, with higher levels of pathogens such as *E. coli*, *Salmonella*, and *Campylobacter*, on produce sold at farmers markets compared with supermarkets (Harrison et al., 2013; Norwood et al., 2019; Sirsat et al., 2015). These findings indicate the need for enhanced food-safety training with refugee growers who are involved in direct-to-consumer markets.

The focus group responses further reflect key principles of community-based development,

Table 1. Language Proficiency, Country of Origin, Crops, and Market Channels of Refugee Growers in Lutheran Service of Iowa and Cultivate KC (*n* = 6)

Characteristics of growers	Responses
Language proficiency of growers	Swahili, Kirundi, Nepali, Burmese, Chin, French
Country of origin of growers	Cameroon, Burundi, Ethiopia, Nepal, Uganda, Burma
Traditional American crops grown by growers	Roselle, watermelons, mustard greens, long beans, kohlrabi, lettuce, tomatoes, broccoli, amaranth greens, squash leaves, turnips, radish, potatoes, onions, garlic, spinach, black nightshade, loofa gourd, Thai chilis
African crops grown by growers	African corn, African eggplant, okra, lenga-lenga
Asian crops grown by growers	Malabar, loofa gourd, bitter melons
Produce market channels of growers	Farmers markets, CSA programs, direct community sales, and occasional long-distance trade

which emphasize improving quality of life, strengthening livelihoods, and fostering sustainability (Samadder & Lal, 2024). Refugee growers' participation in local markets demonstrates how they contribute to culturally relevant local food systems, while also enhancing social and economic connections within their resettled communities. By cultivating culturally significant crops and engaging directly with consumers, these growers reinforce community identity, expand access to diverse foods, and promote economic self-sufficiency, while adhering to the importance of strong food safety practices to support both market access and public health.

Advisory Board Insights on Enhancing Produce Safety Training for Refugee Growers

Interviews with advisory board members revealed consistent themes regarding information accessibility, logistics, produce safety needs, and available resources (Table 2). The advisory board reported that existing produce safety training programs across various organizations generally combine basic on-farm demonstrations and classroom instruction. These sessions typically cover key topics such as hand washing, cooler cleanliness, cleaning harvesting containers, and contamination prevention, aligning with Fetahovic's (2020) findings on common training topics for refugee growers. However, our advisory board members identified a critical need for more comprehensive training in cold-chain management, standard operating procedures, and handling practices for fresh produce.

A significant barrier to effective training identified is refugee growers' limited English proficiency, a challenge also observed by Liu and Eaton (2023),

Table 2. Advisory Board Focus Group Themes and Responses (*n* = 6)

Theme	Responses
Cleaning and Sanitation	"At the farm, we provide training on washing hands, wash utensils, harvest containers, and cooler cleanliness."
	"In-field there is wash station where they actually wash produce."
Insufficient Standard Operating Procedures (SOPs) and resources	"Growers have a hard time keeping it fresh—growers are really interested in how to extend the shelf life of the vegetables."
	"Cold chain storage and understanding the proper storage temperatures for different crops."
	"Standard operating procedures—sanitizing, pests, etc., are needed."
	"Signage at the farm, need regular reminders, separating clean produce from unclean."
Proper Produce Washing Practices	"With American vegetables, food safety gets lost in translation. … There's over washing due to the fear around food safety."
	"Overdo vegetable washing because of fear they've acquired about being food safe."
Produce Safety Protocol for Growers	"For new farmers, basic training is good; they need to understand cleaning practices."
	"Need regular reminders, separating clean produce from unclean, wash hands before and after."
	"Advanced growers need FSMA-level training, especially if they're looking for land or market access."
Language Barriers and Interpretation Needs	"Using children as translators because that's all they have."
Cultural Relevance in Training Materials	"Avoid the use of snakes in videos."
	"Use cultural dresses, wear overalls, straw hat, colorful skirts and dresses, pants, colorful shirts, varied head wear.
Preferred Learning and Communication Methods	"Videos and posters are top two formats needed."
	"WhatsApp, YouTube because it can be sent through WhatsApp text."
	"Short-format videos (3–5 minutes) with multiple language options."

Jarman (2021), and Strohbehn et al. (2018) among Hmong, Nepali, Bhutanese, and Lue Mien produce growers in the U.S. The advisory board recommended short-format videos (3–5 minutes) with multiple language options, visual demonstrations, and culturally appropriate representation featuring farming scenarios that reflect the demographic and cultural backgrounds of the growers as also concluded by Doyle et al. (2023).

The advisory board also emphasized that training materials should be predominantly visual, easily accessible via platforms like YouTube and WhatsApp, and designed with cultural sensitivity in mind, particularly by avoiding imagery that could be traumatic for refugee populations. Various researchers have highlighted the importance of tailoring produce safety training to growers' linguistic, cultural, and technological realities, ensuring that educational resources are both accessible and impactful (LaBorde et al., 2024; Parker, DeNiro et al., 2016; Perez Peguero, 2024).

Refugee Growers' Characteristics

Table 3 provides an overview of refugee growers' characteristics, which includes farming areas and crops grown by growers from different refugee groups. Ten growers participated in the interview; all farm on quarter-acre plots and cultivate various fruits and vegetables (Table 3). This finding aligns with previous studies, such as those by Fetahovic (2020) and Nguyen (2020), which observed that resettled refugees are commonly allocated quarter-acre plots to farm independently as part of broader integration and self-sufficiency initiatives. The uniformity in plot size among growers in this study suggests a structured resettlement approach. Moreover, the crops grown by growers reflect strong ties to their cultural backgrounds. Nguyen (2020) emphasized that refugee growers often cultivate crops that resonate with their cultural heritage. In the current study, growers selected crops familiar to their countries of origin. Similarly, Jarman (2021) highlighted the influence of cultural background on crop selection, noting that refugee growers tend to prioritize culturally meaningful produce.

Refugee Grower Produce Safety Training

During the interviews, growers described several hygiene and produce-safety protocols they have learned and now apply on their farms (Table 4).

Table 3. Refugee Growers' Farming Characteristics (*n* = 10)

Category	Characteristics	Responses
Farming area	Plot size	One-quarter acre
Crops grown	Native American vegetables	Potatoes, pepper, cauliflower, broccoli, tomatoes, daikon radish, eggplant, mustard green, lettuce, cabbage, garlic, onion, beans, cucumber, red onion, amaranth, peas, spinach, squash, sweet potatoes, leeks, carrot, beet, Swiss chard, kale, arugula, green beans, cilantro, snap bean, pumpkin, celery, herbs
	African vegetables	African eggplant, African corn, lenga-lenga, okra, cassava leaves
	Asian vegetables	Malabar, bitter melon, loofa gourd

Table 4. Refugee Growers' Engagement in Produce Safety Training (*n* = 10)

Category	Characteristics	Responses
Prior produce safety training	Attendance	All growers attended produce safety training during winter sessions.
	Topics covered	"For farming they taught us to wear clean clothes. … Cleaning the material that I use to put the vegetables in. … Make sure nobody uses the farm as bathrooms … and when you go to the restroom you need to wash your hands with sanitizer or soap."
		"When I'm working on the farm, and I get cut on my hand, I have to wash my hand, and I have to go to first aid kit and find bandage and if I need to harvest then I have to use gloves or not to harvest on that day."

They reported wearing clean clothing and using separate outfits for different farming tasks to reduce the risk of cross-contamination. Additionally, they emphasized the importance of cleaning and sanitizing storage materials such as crates and containers used for vegetables. Growers in our study also reported using portable washrooms and practicing personal hygiene, such as regular handwashing, to prevent contamination.

These practices were often attributed to produce-safety training received during weekly winter classes, which many growers attended. The classes were delivered primarily by program and market supervisors and by farm management specialists. Interpretation services were consistently provided to ensure linguistic accessibility, and the instructional materials were adapted to support cultural relevance for participating growers. Similarly, Fetahovic (2020) noted that refugee growers commonly engage in produce safety education during the colder months.

In the current research, growers' responses suggest that some key produce safety measures are being implemented, especially those related to minimizing cross-contamination. However, the level of consistency and depth of application varied among growers.

Refugee Growers' Perspectives on Worker Health, Hygiene, and Training on the Farm

Our needs assessment revealed growers' existing knowledge and challenges regarding worker health, hygiene, and training. Recognizing the critical role these factors play on produce farms, the assessment aimed to understand how well growers perceive safe produce handling practices to prevent contamination and health problems. The importance of this understanding is revealed in research by Chen, Kinchla et al. (2021), which highlights that growers themselves can unknowingly harbor and transmit various pathogens, including *Shigella, E. coli, Salmonella*, and *Cyclospora* to produce through contact with hands, clothing, feces, saliva, and blood. Therefore, prioritizing worker health, hygiene, and proper training emerged as a vital strategy to mitigate cross-contamination risks. Our focus group interviews yielded key themes that explain growers' understanding of contamination sources, visitor guidelines, and practices concerning working while ill. These themes, which are detailed below and summarized in Table 5, highlight the growers' current knowledge and reveal areas where enhanced education and standardized protocols are essential to ensure produce safety**.**

The first theme identified was understanding the sources of contamination on the farm. Overall, there was a lack of understanding about sources of contamination. Previously, research has reported limited knowledge among small-scale growers regarding cross-contamination and pathogenic contamination of fruits and vegetables during gardening (Pivarnik et al., 2008; Sinkel et al., 2018). Conversely, in our study, some growers correctly identified animal fecal matter, pets, and manure as sources of contamination on the field. They mentioned that animal fecal matter can contaminate produce, so they collect and dispose of it when it is sighted. They also reported adhering to the 90 and 120 days waiting period after manure application before harvesting to prevent contamination. Furthermore, pets are not allowed on the farm because they were taught during produce safety training that pets can contaminate produce.

The focus group participants had basic knowledge regarding these key food safety recommendations. However, they did not mention water quality and tools as sources of contamination. That observation supports research by Lewis Ivey et al. (2012) that most Midwestern produce growers do not believe that water quality, wildlife intrusion, and failure to sanitize tools and equipment are significant sources of food safety risk. The results in Table 5 indicate a mixed understanding of the sources of contamination on the farm; hence, there is a need for enhanced education on contamination risks.

A theme regarding visitors' guidelines emerged from growers' responses (Table 5). They all expressed uncertainty about how to define a visitor. The confusion around this definition was compounded by the fact that their friends and family members, who occasionally visited the farm, were not recognized as visitors. They only categorized students and extension agents as visitors, so they did not orient their families and friends with produce safety practices, even during their first visit.

Table 5. Themes and Responses from Interviews with Refugee Growers on Worker Health, Hygiene, and Training (*n* = 10)

Themes	Responses
Understanding sources of contamination	"I don't have any idea."
	"Bird poop can carry bacteria."
	"Make sure you look around to see if any animal came to poop in your land. So, you can remove that poop."
	"For example, like these big insects or animals who kind of call it like the raccoons and deer when they invaded the farm and the poop in there."
	"Normally in our culture. We don't have pets in our homes. But they taught us that you cannot take your pet to the farm because when they are walking around, they can contaminate those vegetables.
	"The first rule is the 90 days and 120 days. If you don't follow that when you are using the compost on the manure, you are sure that your vegetables will be contaminated no matter what."
Safe farm visits: Guidelines for visitors on the farm	"Yeah, so our kids, we take them as ourselves. … We don't treat them as employees or visitors."
	"Usually in my farm I don't get many visitors, but I do get many customers at the farm, and I tell them not to step on my farm, not to come to my farm, don't have to harvest nothing just stay there."
	"So, some students who are visiting are curious, they want to see, they want to touch. So, there are gloves, extra gloves we have at the farm, we oblige them to wear those."
	"Yes, we tell them not to bring any kind of animals or pet. Since, they might destroy our plants or other things."
	"I don't allow the visitors to go in the middle of my farm. They must stay outside of the perimeters of the farm."
	"Before you harvest my veggies or produce, you must wash your hands first or I can do it for you. If they need something, I grab it for them."
Ensuring sick worker protocol on farms through best practices and proper communication	"Yes. When anyone is not feeling well or sick, we stay at home until we feel better.
	"Well. I don't really tell anyone on the farm because we don't really communicate, we don't have to tell each other or let them know. If I am sick, I just stay at home."
	"If I feel my body myself heavy, that's the strength of my body is weak, and I feel like a fever. If I have those kinds of things, then I will not go to the farm."
	"If I feel like dizziness or something when I'm working. I do have a phone always and I will call a family member to come and help me."
	"If I feel like I have a severe headache or if I'm having running nose those kinds of things, if I have a diarrhea then I don't go to the farm."
	"If I am sick and I have to go to the farm, I do not go to the wash areas or touch produce."

According to the U.S. Food and Drug Administration (2019), a visitor is anyone other than farm personnel who comes onto the farm with permission. Previous research by Shaw et al. (2015) highlighted the need for growers to clearly set expectations for proper produce safety practices for visitors. Similarly, Parker, Wilson, LeJeune, and Doohan (2012) indicated that visitors should be directed to stay out of the farms to prevent contamination. Research by Astill et al. (2018) emphasized that visitors should be informed about key protocols, including handwashing practices, accessible areas, and farm produce safety policies to ensure safe produce. Therefore, standardized visitor protocols should apply to all farm visitors.

Growers reported avoiding going to the farm when experiencing symptoms of foodborne illnesses, such as diarrhea and fever, as shown in Table 5. They typically stay home and return only after fully recovering. Similarly, Parker, Wilson,

LeJeune, Rivers, and Doohan (2012) and Pivarnik et al. (2008) found that growers prohibit working when sick to prevent produce contamination. In the current study, growers relied on self-evaluation to determine when to return to work. Five growers said they called family members to assist them on the farm when they felt weak during farming hours. Others reported that they sometimes went to the farm while sick but avoided contact with produce. Hamilton et al. (2015) emphasized that restricting ill growers from handling produce is a critical baseline for on-farm hygiene. While growers typically avoid working on produce when sick, a protocol for sick leave is necessary to minimize contamination risks.

Refugee Growers' Understanding and Use of Biological Soil Amendments

All the growers reported using biological soil amendments on their farms. These amendments included manure, compost, and feather meals (Table 6). These reported biological soil amendments are like those used by growers in research by Pires et al. (2018). Most of the growers in our study demonstrated limited awareness of the risks associated with using these amendments. Five growers mentioned the 90- and 120-day waiting periods for applying untreated biological soil amendments before harvesting crops but could not differentiate which crops required 90 days versus 120 days. In line with previous research by Pires et al. (2018), most organic produce growers surveyed in their multiregional U.S. study adhered to the waiting period before harvest. However, in our study and in previous research by Strohbehn et al. (2018), growers did not understand the rationale for the waiting period when asked. In our study, three growers attributed the waiting period to crop yield and income. Meanwhile, three others reported tracking manure application dates to comply with the 90- to 120-day rule. Most growers in our study did not maintain formal documentation of soil amendment applications. This finding is consistent with previous studies by Adalja and Lichtenberg (2018) that only a third of growers kept records of soil amendment application dates. Similarly, Laury-Shaw et al. (2015) identified proper documentation as a key challenge for small-scale growers. The need for improved manure application practices and documentation was evident among refugee growers, highlighting the importance of providing targeted educational resources and support for this group.

Refugee Growers' Perceptions and Practices on Agricultural Water Use

All the growers reported obtaining agricultural water from municipal sources (Table 7). However, none of the growers could explain the importance or reasoning behind water testing. They stated that because they use the same municipal water at home for domestic chores and drinking without experiencing health issues, they see no need for testing. This supports research by Hamilton et al. (2015) and Lewis Ivey et al. (2012) that less than half of produce growers strongly agreed that agricultural

Table 6. Theme and Responses from Interviews with Growers on Biological Soil Amendments of Animal Origin (*n* = 10)

Theme	Responses
Understanding the risks and appropriate use of biological soil amendments	"I don't really know about the risk but for me personally using compost or other don't make people sick because it is organic. We share our veggies with family and friends, and they are fine."
	"I use manure, compost, fertilizer, and feather meal. … I wait some 1 week, 2 week, or a month depending on the crop."
	"It will affect somehow the growth of the vegetables, some will grow taller without the product you expect, some will be shorter or take long time to produce fruit, those will affect the income you expect to have, so if you want to be successful, you need to wait, you need to follow those days 90 and 120."
	"The kind of compost or manure we use cannot be dangerous."
	"When we deposit the manure, they [the growers] write down the date."

Table 7. Theme and Responses from Interviews with Growers on Agricultural Water (*n* = 10)

Theme	Responses
Ensuring microbial safety of water	"Use the city water, the water that people normally drink in their homes."
	"We run the farm by rivers, but we never use the water from the rivers, so the city we are sure they test the water and also we drink from that same water, so it is really clean water."
	"It depends on the vegetable and how many times we have to change water."
	"We have three sinks, put water in the first sink, once you pull out the vegetables, put them in the second sink, you open the first sink for the water to go, then you refill the sink, so you can wash the second vegetables, and you keep doing the same until the produce are clean."
	"One vegetable wash three times then you start over with new set of vegetables."
	"It doesn't matter how many times, if you still see that they are not clean yet, you will redo and redo and redo until you see they are really clean."
	"We do not use sanitizer."
	"We dispose of the water by draining it through the pipes."

water was a potential source of contamination. In the present study, three growers noted that municipal water is tested before being distributed to the public, reinforcing their belief that additional testing is unnecessary. It aligns with the findings of Chen, Kinchla et al. (2021), who reported that produce growers often have limited knowledge of water-testing requirements, including the required test types, testing frequency, and result interpretation. However, one grower with surface water near the farm stated that he does not rely on municipal water for farming activities to prevent contamination.

In the present study, growers use water for various tasks, including irrigation and washing. At the washing station, produce is rinsed in a sink without adding antimicrobial agents, such as sanitizers. To prevent contamination, they frequently change the washing water based on the type of produce, the volume being washed, and the level of soiling. Similarly, Tong et al. (2017) reported that growers changed the wash water when it was dirty. Growers ensure that produce is washed thoroughly before disposing of the used water down the drain. These findings highlight an opportunity to educate growers on the significance of water testing and its role in produce safety.

Overall, the focus group data offers valuable insight into growers' current food safety practices and highlights key knowledge and practice gaps that could pose produce safety risks to both the industry and consumers. These findings can guide improvements to local and national produce safety education programs, particularly those serving linguistically and culturally diverse grower communities. In particular, the clear need for multilingual, highly visual, and culturally responsive educational materials indicates that existing, federally standardized training frameworks such as the Produce Safety Rule (PSR) Grower Training may require greater flexibility and adaptation to reach refugee growers more effectively.

Limitations

This study has limitations. Although the research was carefully designed and implemented, the sample size was small ($n = 10$). The study included two groups of growers, Asian ($n = 4$) and African growers ($n = 6$), which could have introduced bias, leading to the underrepresentation of other growers. Also, the findings from this study may not be generalizable to the broader refugee population, particularly those from different geographical regions or countries of origin. Future research could expand this scope by incorporating refugee growers from broader geographic areas in the Midwest and by increasing the sample size.

Conclusion

This study highlights the need for targeted produce safety education tailored to the linguistic, cultural, and experiential backgrounds of refugee growers. While growers demonstrated foundational knowledge of hygiene and sanitation practices, the

findings reveal significant gaps in understanding and applying key produce safety standards, particularly regarding sources of contamination, sick-worker guidelines, biological soil amendments, visitor protocols, and agricultural water testing. These knowledge gaps pose challenges to fully complying with FSMA PSR guidelines and may hinder safe produce-handling practices.

Advisory board members of the refugee growers expressed the growers' preference for accessible and culturally relevant educational resources, such as short, visually driven training videos delivered via platforms like WhatsApp and YouTube, indicating a strategic opportunity to design and implement produce safety messages that resonate with refugee growers.

The results of this study highlight a critical need to support the development of effective produce safety messaging strategies. Educational resources should reflect the cultural identity of the target audience, accommodate limited English proficiency, and simplify complex produce safety regulatory language. Future interventions should prioritize co-creating resources with advisory board members and using an iterative feedback loop to ensure relevance and impact.

By aligning content delivery with the growers' communication and cultural preferences, these tailored resources can help bridge knowledge gaps, improve produce safety compliance, and strengthen the overall sustainability of refugee farming operations in the Midwest.

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Urban farms represent highly heterogeneous environments, complicating on-farm food safety efforts

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Abstract

Urban agriculture is increasingly recognized for its capacity to mitigate food insecurity and to contribute to the development of more sustainable and equitable food systems, yet microbial and chemical pre-harvest food safety risks in urban farms remain underexplored in the United States. To address this gap, we surveyed 43 urban farms across 12 cities in three U.S. growing regions. Semi-structured interviews, field walk-throughs, and follow-up reviews of each farm's social media presence were used to characterize farm practices and histories as well as grower perspectives on microbial and chemical hazards. Findings revealed substantial heterogeneity between and within farms. Many farms prioritized community empowerment, education, and food access. Growers frequently expressed concern about legacy chemical contamination but reported limited training or awareness of microbial hazards. Structural constraints, such as insecure land tenure, limited resources, reliance on volunteers and donated materials, and staff turnover, further complicated consistent implementation of food safety measures. Improving food safety outcomes in urban agriculture will require flexible, field-specific risk assessment, alongside policies and technical assistance that address both knowledge gaps and structural barriers facing urban growers.

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Additional author details and funding disclosure on next page.

Keywords
urban farms, food safety, heavy metals, chemical hazards, microbial hazards, sustainability

Introduction

Urban agriculture is increasingly recognized for its capacity to mitigate food insecurity and to contribute to the development of more sustainable and equitable food systems (Nogeire-McRae et al., 2018; Siegner et al., 2018). Urban farms (UF) vary widely in form and scale, ranging from small backyard gardens to large food forests and controlled environment operations (Feldmann et al., 2023; Specht et al., 2014). Despite the potential socioecological benefits associated with urban farming (Orsini et al., 2020; Specht et al., 2021; Zasada, 2011), UF microbial food safety remains underexplored in the United States.

Studies on large-scale, commercial operations have shown that there are diverse, on-farm pathways for the introduction of microbial hazards, including the use of untreated biological soil amendments of animal origin or untreated irrigation water and wildlife intrusion into produce fields (Lee et al., 2019; D. Weller et al., 2015; Xiong et al., 2025). While UF operations are also susceptible to these routes of contamination, specific pathways and risks likely differ between urban and conventional farms due to differences in surrounding land use, operational models, and farm missions. Many UFs also fall below the sales thresholds for compliance with the federal Produce Safety Rule (PSR), and participation in voluntary Good Agricultural Practice (GAPs) programs is driven by market rather than regulatory requirements. A nationwide survey of urban farmers found that almost half earned less than US$10,000 annually (Pressman et al., 2016); farms are PSR exempt if annual sales are less than US$25,000 (U.S. Food and Drug Administration, 2024). Thus, UF practices are likely implemented under different regulatory or market expectations than large-scale, commercial operations. To better inform application and adaptation of existing GAPs and related frameworks to UF food safety, a comprehensive understanding of UF practices is needed.

UFs may also face unique food safety hazards that are not typically a concern for conventional farms. Many UFs operate on repurposed land with complex histories, resulting in legacy chemical contamination (e.g., from industrial activity; Yesilonis et al., 2008; Y. Zhou et al., 2020; Ziss et al., 2021). Because UFs are often near highways, railroads, active industry, or aging infrastructure, there is also the potential for the ongoing introduction of chemical contaminants. Proximity to residential or recreational areas could introduce the potential for novel microbial contamination from trespassers, litter, urban pests, or pets (Kopiyawattage et al., 2019; Sollins, 2016; Wijburg et al., 2025). Despite these unique hazards, UF food safety, particularly microbial, remains underexplored in the USA. Many studies of urban agriculture have focused on chemical hazards, and a substantial portion of the broader UF food safety literature has been conducted outside the USA (e.g., Entwistle et al., 2019; Taylor et al., 2021; Y. Zhou et al., 2020). In comparison, fewer studies have examined microbial hazards (Lupolt et al., 2021; Spliethoff et al., 2016). The existing literature, therefore, demonstrates the potential for microbial and chemical hazards to occur on UFs, but additional research is needed. This study addressed this gap by characterizing on-farm

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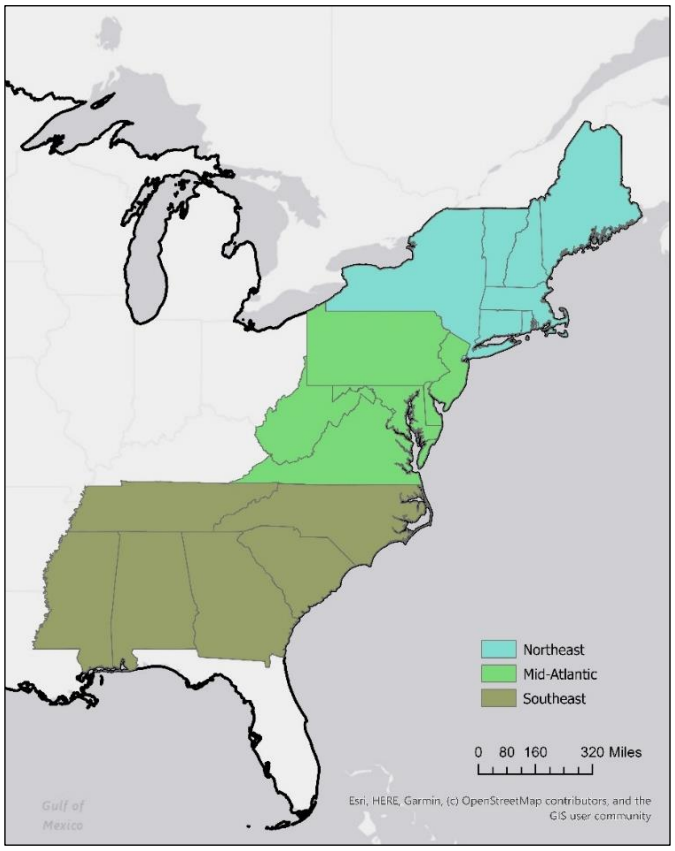
Figure 1. States Considered Northeastern, Mid-Atlantic, and Southeastern for the Purposes of this Study



Note that 19 states are highlighted, but farms in seven states were sampled. This was done to ensure confidentiality due to the small number of urban farms in some states.

practices that could impact chemical and microbial hazard presence, in the context of farm history and grower priorities and perceptions.

Materials and Methods

Forty-eight UFs representing 12 Eastern USA cities were enrolled; five farms withdrew due to the COVID-19 pandemic (Figure 1). Farms were recruited through snowball sampling, beginning with existing contacts. The number of farms recruited in each city varied by city size, the number of UFs in each city, and our existing network in each city. For example, nine farms in City A enrolled, representing 18% of UFs there, while two farms from City B enrolled, representing all City B farms.

Between July and November 2020, each farm was visited once, and an approximately 45-minute semi-structured interview conducted. To inform the interview, we emailed growers before each visit to gather information on farm size, history, organic status, mission, organizational structure, and market channel.

After each interview, a walk-through was conducted to get detailed information on the practices used in a randomly selected subset of beds. Standard questions about land use history and management practices during the last 365 days were asked (Supplemental Figure S1). To select beds for inclusion, farm maps were obtained before each visit and used to delineate fields and beds in ArcGIS. Fields were defined as any land used for horticultural production in the last year (e.g., fields, orchards, high tunnels), including mixed-use plots where horticulture occurred alongside other activities, such as cuniculture. Fields were grower-defined and included at least one bed. Beds were defined as a single management unit:

1. with a shared land-use history,
2. where the same crop or crops were cultivated, and
3. where the same management practices were used during the last 365 days.

GPS coordinates were randomly generated within bed areas using ArcGIS. Beds containing a random point were visited during the walk-through. The number of beds ranged from five for farms less than 0.1 acre (0.04 hectares) to 70 for farms greater than 3.0 acres (1.2 hectares; Figure 2).

Follow-ups were conducted by phone or email, if needed. Farm websites and social media were reviewed to collect information on organizational structure and farm mission.

The data collected were used to generate two tidy datasets. The first captured farm-wide data (e.g., on market channel, organizational structure, food safety training, mission, and farm history). Land-use data for propeties immediately adjacent to each farm[1] and socioeconomic data for each farm's census tract[2] were included in this first da-

[1] https://www.mrlc.gov/data

[2] https://www.ahrq.gov/data/innovations/clh-data.html

taset. The second dataset focused on bed-specific practices, such as if, how, and when a bed was last irrigated or amended.

Results

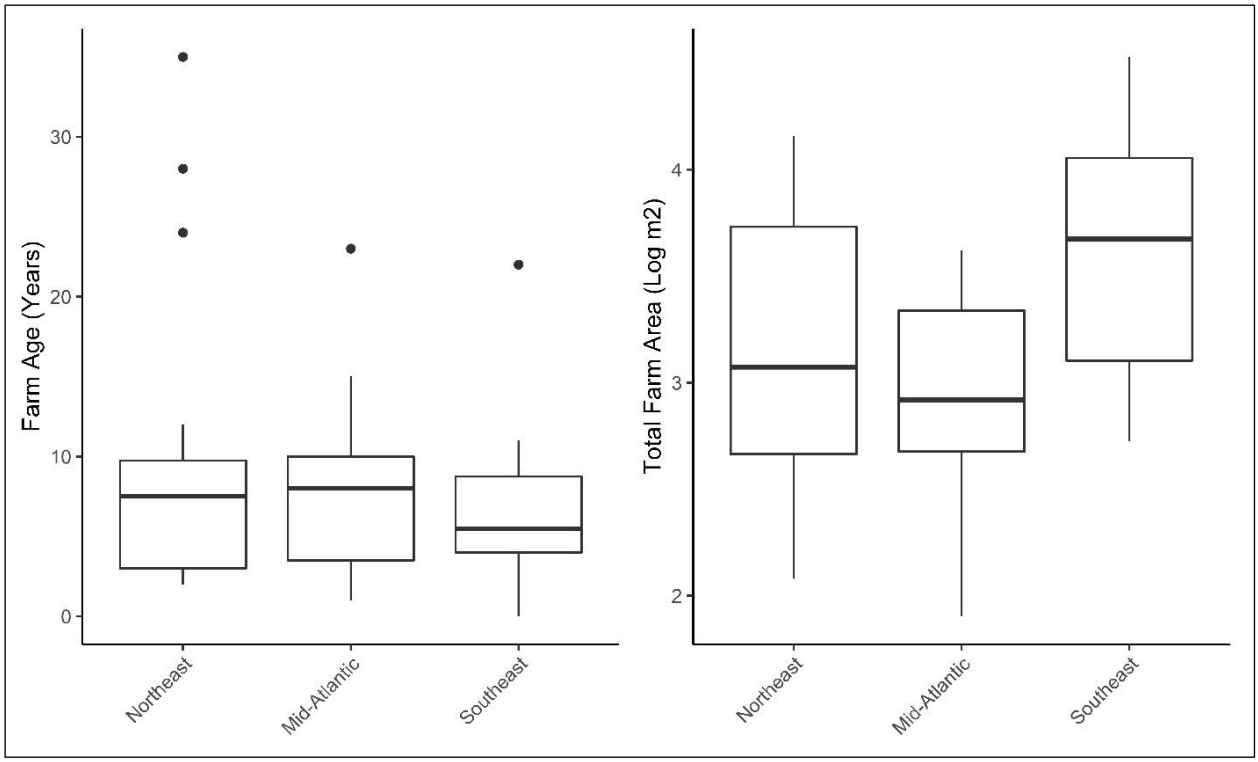
Data were collected from 43 UFs (Northeast = 18; Mid-Atlantic = 11; Southeast = 14; Table 1). Several farms were operated by a single parent organization but functioned independently and had different farm managers, market channels, and missions. Regional and city-specific patterns were observed. However, practices, perspectives, and challenges varied substantially at all scales, including within and between farms, fields, and beds, and over time.

Farm Missions

All farms had a defined mission, most of which were public and outward-facing, reflected through the farms' strong social media and community presence. Many farms emphasized supporting underserved or historically marginalized communities (Northeast = 83%; Mid-Atlantic = 55%; Southeast = 79%), a commitment that often reflected the socioeconomic characteristics of the neighborhoods where the farms was located (Figure 3).

Farm missions often reflected how, why, and by whom the farm was founded. Some farms were established by the communities they served, which created a strong connection between the farms and their communities. Other farms began as nonprofit arms of for-profit companies or through municipal green space programs. Thus, farm missions often focused on community needs (e.g., education, environmental justice, food security, community empowerment) rather than commercial-scale food production. Fifty-six percent of farms had missions emphasizing education, including programming on gardening, entrepreneurship, activism/leadership, and nutrition, as well as afterschool programs, youth internships, and collaborations with schools and community groups. UFs' community-focused missions also often translated into activities that reflected community priorities, including preserving heirloom seeds, growing medicinal herbs/

Figure 2. Distribution of Farm Age and Area by Region for the 43 Sampled Farms (Northeast = 18 farms; Mid-Atlantic = 11 farms, Southeast = 14 farms)



dye plants, and improving food access for cancer patients.

Market Channels

Growers reported >15 distinct channels, including donation (60%; e.g., to food banks), on-site sales (53%), community-supported agriculture (30%), and wholesale (26%; e.g., to grocery stores, restaurants; Table 1). Forty-two percent of farms included a "direct provision" channel in the form of community gardens (33%) and food forests (9%). Farms often combined growing and distributing farm products with other activities, such as renting space to other businesses or teaching classes for a fee.

Workers and Volunteers

The number of persons, including paid workers,

Table 1. Summary Statistics for the Surveyed Farms by Region

	Farms (%)							
	By Market Channel/Food Distribution Method [a, b]							
Region (No. of farms)	Comm. Garden [c]	Direct-to-Consumer [d]			Donate [e]	Other [f]	Food Forest	Wholesale [g]
		CSA	Off-Site	On-Site				
Northeast (18)	44	33	39	67	72	50	6	17
Mid-Atlantic (11)	18	36	45	45	55	45	18	45
Southeast (14)	29	21	43	43	50	50	7	21
Overall (43)	33	30	4	53	60	49	9	26

	Whose Mission Emphasizes			By Organizational Type				
				Independent, For-Profit [j]		Nonprofit [k]		
Region (No. of farms)	Access to Green Space [h]	Education	Support for Underserved Comm.[i]	Commercial	Hobby	Comm. Org. or Co-Op	Govt.	NGO
Northeast (18)	72	61	83	11	6	22	0	67
Mid-Atlantic (11)	36	45	55	9	9	18	18	64
Southeast (14)	36	57	79	29	7	7	7	50
Overall (43)	51	56	74	16	7	16	7	60

[a] These are presence-only data obtained from (a) grower interviews, (b) on-site observations by the researchers, and (c) review of the farm's web presence.

[b] Key revenue sources not captured here include (a) individual or corporate donations of time, money, and resources, and (b) grant funding from local, state, and federal agencies and non-governmental organizations, including research grants (e.g., Sustainable Agriculture Research and Education) submitted independently and in collaboration with academic partners.

[c] Comm. = Community; Community Garden includes both community gardens and cooperative (co-op) gardens.

[d] CSA = Community shared agriculture. Off-site = includes but is not limited to selling through farmers' markets, mobile markets, pop-ups, and other venues. On-site = farm stand or store.

[e] Includes donating food and non-food products directly to individuals (e.g., free food boxes), distribution centers (e.g., food banks), and nonprofits, and selling food at reduced cost. Several farms foraged produce from public areas around their city, which they donated. Many farms accepted WIC and SNAP benefits.

[f] Includes u-picks; growing and selling nursery plants and/or Christmas trees; selling other products raised/made on-site, off-site, or by another group (e.g., seeds, animal products, medicinal herbs/salves, fermented products, teas, wine, syrups, cider, spice mixes, handicrafts); providing landscaping services; charging for field trips (as opposed to providing educational access for free); teaching courses for a fee; or renting to other businesses (e.g., art/yoga studios).

[g] Includes selling, for profit, to restaurants, distribution centers, and other groups.

[h] Includes farms whose mission explicitly includes providing recreational, green, or open space. These farms were often partially fenced or fully unfenced, and frequently incorporated ecosystem stewardship into their missions.

[i] Support for underserved communities includes efforts to address food insecurity and improve access to food, employment, community resources, green space, and culturally relevant foods for historically underserved populations.

[j] Independent for-profit companies were either commercial farms or hobby farms. Hobby farms were (a) operated by individuals whose primary occupation was not farming, (b) sold produce for profit, (c) did not have a philanthropic mission, and (d) tended to have fewer resources or support than commercial farms.

[k] Nonprofit farms fell into three categories: those operated by government agencies, nonprofit organizations (including churches, hospitals, and philanthropic organizations), and community groups. Resource availability varied across organization types.

volunteers, and community gardeners, on each farm varied (Table 3). Farms with community gardens, educational missions, and a reliance on volunteers generally reported more persons on-site. For-profit farms generally reported fewer, and hobby farms the fewest.

Many farms relied heavily on volunteers, interns, or temporary workers. One organization operating five Northeastern farms was staffed primarily by AmeriCorps volunteers, with long-term continuity supported by a strong community volunteer network. More broadly, volunteer models varied across regions, with Northeastern farms tending to "ask less of many" volunteers, whereas Mid-Atlantic and Southeastern farms often relied on deeper commitments from fewer individuals.

Crop Diversity

Although crops such as peppers, tomatoes, and strawberries were common across farms, substantial varietal diversity was observed. Overall, more than 190 different plant species were cultivated by participating farms (Supplemental Table S1). There were distinct regional and municipal patterns in the crops grown, reflecting local climate, culture, and environment. Crops also sometimes reflected the farm's mission or the grower's personal identity or interests, or those of the communities the farm served. The primary mission of the farm with the greatest tree crop diversity was to act as a publicly accessible food forest, while the farm cultivating rice, sugarcane, and stevia marketed these crops as seed stock and nursery plants instead of food products. The only farms cultivating pigeon pea and long bean primarily sold to Caribbean and Nepalese communities, respectively. Crops could also reflect a farm's structural constraints. For example, a farm with limited acreage grew fruit salad trees (trees with multiple related species grafted to them).

Land Use History

Many farms had long and varied histories (Table 2). One Southeastern farm, for instance, was established on land that had been a colonial-era mine and later became, in order, a church, school, shooting range, home, and parking lot. Multiple farms described their history on their website or social media. Growers with the most detailed farm history knowledge had (a) institutional support to

Figure 3. Socioeconomic Characteristics of the Census Tracts in Which the Farms were Located

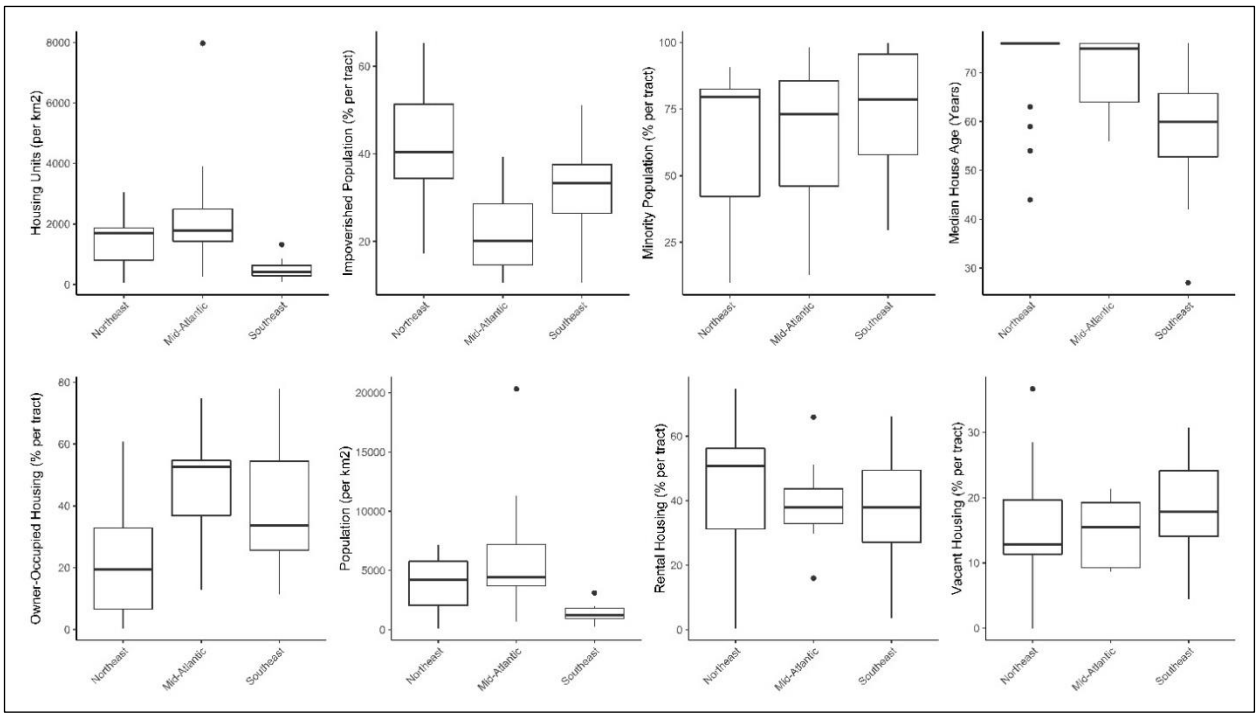


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Table 2. Urban Landscape Around Each Farm, Including Past Land Use on Each Site (if Known), Adjacent Land Use (as Reported by the Grower or Interviewer)

Many farms had complex land histories with different parts of the farm being used for different purposes at different times.

	On-Farm Land Use and Land Cover (% of Farms) [a]							
	Historical [a]					Current		
Region (No. of Farms)	Agricultural [b]	Dump Site [c]	Industry [d]	Park or Forest	Resid/Comm. [e]	Fenced in [f]	Non-Crop Veg. [g]	Wind Breaks [h]
Northeast (18)	0	17	11	11	83	61	56	28
Mid-Atlantic (11)	18	18	18	18	55	64	45	100
Southeast (14)	23	14	29	21	57	79	79	50
Overall (43)	12	16	14	16	67	67	60	53

	Land Use and Land Cover on Parcels Surrounding Farm (% of Farms)								
							Surface Water		
Region (No. of Farms)	Forest-Wetland	Highway	Industry	Mowed Fields	Resid/Comm.	Park	Lake/Pond	Stream/River [k]	Vacant
Northeast (18)	11	33	11	44	94	17	17	8	22
Mid-Atlantic (11)	0	9	36	27	91	18	0	0	36
Southeast (14)	43	29	36	21	100	14	7	43	36
Overall (43)	19	26	26	33	95	16	9	23	30

[a] Most plots of land have held multiple structures over the years, and it was difficult to ascertain the type and duration of past structures, or the age of current structures, with the information available.

[b] "Agricultural" refers to land that was either used as pasture or cropland.

[c] Junkyards and other lots where non-organic refuse was dumped or used as infill. For example, one Southeastern farm is downhill of several automotive shops and partially overlaps a former railroad yard; both the shops and railroad dumped refuse, including machinery and car parts, on the current farm site.

[d] While only 14% of farms were on land used for industrial purposes, the type of industry varied considerably, including galvanized steel plants, pallet factories, saw mills, railroad yards, mining, car repair shops, and bus depots, among others.

[e] Resid = residential. Comm = commercial.

[f] All or part of the farm is fenced in, and the fence was sufficient to prevent people and dogs from entering the growing area.

[g] Non-crop vegetation was considered to be present if a substantial amount of non-crop, non-ornamental plants, including grasses, shrubs, and trees, were present and could function as wildlife habitat. Farms were counted if non-crop vegetation was observed around one or more of the fields visited.

[i] Windbreaks included rows of trees or shrubs, or elemental structures (e.g., sheds, houses) that blocked the wind, and would inhibit the movement of airborne contaminants into the growing area. Farms were counted if windbreaks were observed around one or more of the fields visited.

[k] One Mid-Atlantic farm was built on top of an enclosed and channelized stream. While the subsidence of the infill placed on top of the buried stream created unstable foundations and resulted in the abandonment of the property in the 1970s, this farm is not included in the percentage here since the stream remains enclosed and inaccessible by humans or wildlife.

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Table 3. Short Description of Growing Practices Across Regions [a]

	Growing Practices (% of Farms)										
	Growing In [b]				Soil Barriers						
					Used for						
			Raised [c]		Raised			Made of [d]			
Region (No. of farms)	High Tunnels	In-ground	Beds	Rows	In-ground	Beds	Rows	Cardboard	Fabric	Other	Plastic
Northeast (18)	33	72	78	44	45	64	75	64	36	18	36
Mid-Atlantic (11)	27	64	45	27	0	80	0	50	25	25	0
Southeast (14)	21	100	74	36	7	44	20	25	50	75	50
Overall (43)	28	79	65	37	18	61	44	53	37	32	32

	Raised Beds													
		Material (% of Farms) [e]							Percent of Farms Using, in ≥ 1 Field,					
									Tillage [f]					
										< 1 Year				
Region (No. of farms)	Mean Height (in.; SD; Range)	Brick	Concrete	Metal	Plastic	Recycled Materials	Stone	Wood	Never	No	Yes	Perma-culture Practices	Low Tunnels [g]	Median No. of Workers (IQR)
Northeast (18)	11.6 (4.4; 6.0-26.0)	0	7	0	14	40	0	86	100	0	24	77	11	15 (4–35)
Mid-Atlantic (11)	18.1 (9.0; 5.0-28.0)	20	20	0	0	7	0	100	56	22	100	77	27	4 (2–6)
Southeast (14)	17.8 (15.6; 6.0-91.4)	11	11	22	11	22	7	100	85	15	62	93	14	6 (3–10)
Overall (43)	14.2 (9.2; 5.0-91.4)	7	11	7	11	18	4	93	85	10	54	79	16	6 (3–19)

[a] For each growing practice, a farm was counted in the percentage if the practice was used in ≥ 1 bed.
[b] A farm was counted in these percentages if ≥ 1 field was grown using the given approach.
[c] Raised rows were built from a variety of materials, including soil (from the farm site and from other locations), logs, wood chips, straw, manure, and compost, often using hügelkultur approaches.
[d] The denominator for these percentages is the total number of farms using soil barriers for the given region. Two farms each used (a) wood chips and cardboard together, (b) gravel, and (c) metal (e.g., old roofing). One farm each used (a) wood chips, (b) coconut husk plus cardboard, (c) concrete, (d) recycled plastic drums, and (e) and pond liners.
[e] These are broad categories for the materials raised beds were constructed of. However, within these categories, there was considerable variation. For example, the wood used to build raised beds included new and recycled treated, untreated, and painted wood as well as various wood types (e.g., bamboo, cedar, pine).
[f] In fields where permaculture practices were used, orchards, raised beds, and raised rows were not included in the denominators when calculating these percentages since tillage would not normally be practiced as part of these growing practices.
[g] Low tunnels and shade cloths.

Table 4. Short Description of Soil Amendment and Soil Cover (e.g., for Weed Suppression) Practices [a] [b]

	Soil Amendments Used on Site (% of Farms)											
	Animal Origin [c]							Plant-Based [f]				
				Poultry								
Region (No. of farms)	Blood Meal	Bone Meal	Other BSAAO [c]	Poultry Litter	Other	Chemical Fertilizer [d]	Minerals [e]	Alfalfa Meal	Brewer's Grains	Charcoal and Ash	Com-post [g]	Seaweed Emulsion [h]
Northeast (18)	0	0	27	11	0	39	6	6	0	0	89	11
Mid-Atlantic (11)	18	18	9	9	9	18	27	9	0	0	82	36
Southeast (14)	0	0	7	21	7	43	29	0	14	7	86	57
Overall (43)	5	5	14	14	5	35	19	5	5	2	86	33

	Soil Covers Used										
Region (No. of farms)	Black Plastic [i]	Cardboard[j]	Cover Crop [k]	Fabric	Leaves	Mulch	Peat Moss	Pine Straw	Salt Hay	Straw	Weeds
Northeast (18)	22	28	22	11	11	78	0	0	0	44	11
Mid-Atlantic (11)	36	27	45	0	45	82	18	18	18	27	45
Southeast (14)	43	21	64	14	71	86	0	29	0	50	43
Overall (43)	33	26	49	9	40	81	5	14	5	42	30

[a] For each growing practice, a farm was counted in the percentage if the practice was used in ≥ 1 bed.

[b] Due to poor soil quality or contamination concerns, most farms brought in large quantities of soil (e.g., as part of raised bed/row construction, to supplement existing soils, to replace contaminated soils that were removed). Several farms reported continuing to amend or top-dress with imported soil.

[c] Biological soil amendments of animal origin (BSAAO) from sources other than poultry litter and fish-containing seaweed emulsions. Other BSAAOs were often donated by local hobby farmers or livestock operations. Several farms with rabbits on site used the rabbit pellets as an amendment.

[d] Includes organic and nonorganic fertilizer mixes, such as Super N, Cheep Cheep, and Osmocote.

[e] Amendments such as boron, carbonate, azumite, and gypsum.

[f] Raised beds and raised rows built using plant material (e.g., logs, straw bales, wood chips, leaves) were not included in the numerators here since the use of these materials occurred more than 2 years before the survey was performed, and/or "amendment" with these materials was concomitant with creation of the raised bed/row.

[g] Includes, but not limited to, materials composted on site, vermicompost, and compost from commercial mushroom production. Multiple farms reported using food scraps for their compost, and some solicited food scrap donations from community members. Both treated compost and untreated compost were used.

[h] Some seaweed emulsion also included fish.

[i] Several growers reported tilling in their black plastic.

[j] Many growers reported that cardboard decayed over the course of the growing season and would be fully or partially integrated into the soil during tillage.

[k] Cover crops included buckwheat, clover, oats, sorghum, sunflowers, and vetch, among others. Several growers also used perennial herbs, mowed grass, and non-crop vegetation as cover; if these areas are excluded from the numerator, then the proportions become 17%, 45%, and 35% for Northeastern, Mid-Atlantic, and Southeastern farms, respectively.

research it, (b) concerns about legacy chemical contamination, and/or (c) strong ties to the local community, which provided access to oral accounts or personal records. A minority of growers in the Northeast and Mid-Atlantic obtained information from government partners or municipal websites.

Almost all growers knew the most recent land use and structures present before their farm was established, but fewer knew about earlier land uses or structures. Even when knowledge of earlier land uses was limited, on-farm structures often reflected the history of the surrounding neighborhood and city. Within a single city, a farm located in the historic downtown was on the site of a former apartment complex, while a farm in a historically industrial neighborhood had previously held an ice-house, canal, rail yard, gas station, and single-family homes. Similar patterns were observed across the study. The five farms with agricultural legacies were all located in historically peri-urban or exurban areas that urbanized rapidly during the late 20th and early 21st centuries. Although the details of past agricultural activities were often difficult to reconstruct, most retained legacy fruit trees, and one food forest occupied the site of a former horse pasture.

Horticultural Practices

Production systems varied substantially across farms and included growing produce inground (79%) and using raised beds (65%), raised rows (37%), high tunnels (28%), and low tunnels or shade clothes (16%; Table 3). One farm used container production, and one used straw-bale production. Raised rows were made of mounded organic matter built using hügelkultur principles. Raised beds varied in composition, shape, size, and age (Table 3). Much of the material used to build raised beds was recycled or donated, including plastic bakery carts, pond liners, landscaping fabric, pallets, railroad ties, and downed trees, as well as waste brick, concrete, stone, metal roofing, and fencing.

Soil Barriers

Soil barriers were used for in-ground, raised-bed, and raised-row production to suppress weeds and reduce contact between production soils and underlying endemic soils that might contain legacy chemical contaminants (Table 3). Cardboard, burlap, and plastic were the most common materials used, but growers also reported using wood chips, coconut husk, concrete, gravel, and metal sheeting, reflecting opportunistic use of materials on hand.

Soil Covers and Cover Crops

Most farms used soil covers in at least one bed to suppress weeds, support soil fertility and moisture retention, and protect crops during winter (Table 4). Although most farms used multiple cover types, the most common, in order, were wood chips and mulch (81%), straw (42%), leaves (40%), black plastic (33%), chopped weeds or other vegetative material (30%), and cardboard (26%). Certain covers were more common in certain regions and cities. Pine straw was used by 29% of Southeastern farms, while salt hay was only used by farms in one coastal Mid-Atlantic city.

Forty-nine percent of farms used cover crops (Supplemental Table S1). Several growers used perennial herbs (e.g., mint, thyme), mowed grass, and other non-crop vegetation as cover crops in mixed-use plots, livestock pens, and orchards (Table 4).

Soil Amendments

All farms used soil amendments, with the most common being compost, chemical fertilizers, seaweed emulsion or fish meal, and minerals (Table 4). Even within a single farm, amendment use varied across beds according to crop needs and amendment availability. Many amendments were obtained through donations or local partnerships and selected based on availability and sustainability goals rather than standardized food safety criteria. Some were intermittently available as waste products from local businesses (e.g., spent brewer's grain, coffee grounds), other farm enterprises (e.g., rabbit manure, mushroom compost), or community donations (e.g., untreated or composted manure from hobby farms).

Irrigation Practices

All farms used irrigation in at least bed, but most also maintained unirrigated production areas, most commonly orchards, mixed-use areas, and perma-

culture beds. Most farms used a combination of hand, drip, and overhead irrigation across different production areas, depending on crop needs and available infrastructure (Table 5).

Municipal water was the most common irrigation source, although a minority of growers used untreated surface water. The only Northeastern farm irrigating with surface water drew its water from a creek with a documented history of microbial impairment, of which the grower was unaware. Several growers also collected rainwater through roof-catchment systems or rain barrels, although one reported using roof-collected rainwater only on nonedible crops because of concerns about contaminants from roofing materials.

Livestock and Wildlife

Many farms raised livestock on the same property as their produce production (Table 6). A small number of Southeastern farms raised animals, including ducks, goats, alpaca, and emus, on noncontiguous properties not sampled here. Companion animals were also common, and several farms allowed visitors to bring dogs on site. Growers noted, and researchers observed, intrusion into fields of domestic animals owned by farm staff and by unaffiliated persons (e.g., neighbor's dog, stray cat). Several growers used livestock or pets (e.g., chickens, cats, dogs) for pest management or other livestock for fertilization (e.g., rabbits, chickens). Wildlife intrusion was also widespread; growers reported, and researchers observed, animals such as raccoons, groundhogs, deer, coyotes, foxes, opossums, skunks, reptiles, amphibians, and songbirds visiting production areas. Although animals are recognized in the GAPs framework as potential sources of microbial food safety hazards, no growers expressed food safety concerns about the presence of domestic animals on-farm or within fields, and relatively few expressed concerns about wildlife intrusion.

Intra-Farm Heterogeneity

Many farms contained multiple zones of activity that did not always follow field and bed boundaries, and a single area often supported multiple, overlap-

Table 5. Short Description of Irrigation Practices and Other Considerations Relevant to Microbial and Chemical Food Safety

	Heavy Metal Contamination (%)		Irrigation Practices (%) [c]							
			Water Source				Method [f]			
Region (No. of farms)	Expressed Concern [a]	Past Testing [b]	City [d]	Rain [e]	Surface Water	Well	Drip	Hand	Overhead	With Handwashing Facilities
Northeast (18)	44%	44%	83%	39%	6%	11%	39%	39%	44%	61%
Mid-Atlantic (11)	36	18	91	27	0	0	36	73	9	55
Southeast (14)	36	14	57	86	7	36	57	57	14	86
Overall (43)	40	28	79	51	5	16	44	53	26	67

[a] This refers to a farm that expressed concerns during the site visit. These percentages may therefore underestimate the number of growers who were aware of chemical contamination risks due to historical or current land use in the farm area.
[b] Includes farms where testing has occurred ≥ 1 times, and where testing was done by the grower, extension, or a government agency (e.g., the city government or EPA as part of soil remediation).
[c] For each growing practice, a farm was counted in the percentage if the practice was used in ≥ 1 bed. One Mid-Atlantic and one Southeastern farm were in the process of being established, and irrigation had not yet been set up at the time of the farm visit.
[d] Includes both city water available through on-site connections and water made available by adjacent landowners (e.g., neighbors, a library, an office complex, a fire station).
[e] Includes farms that actively harvest rainwater for use in irrigation (e.g., roof rain collection system, rain barrels), and farms that did not perform active irrigation (e.g., relied on direct rainfall; mainly in orchard and permaculture areas).
[f] Hand irrigation includes irrigating using a hose, watering can, or other container. Spray irrigation includes any form of overhead, spray, or sprinkler irrigation.

ping functions (e.g., orchards were also used for community gatherings, grazing chickens, or herb and flower production). As a result, management practices frequently differed over short distances within the same farm. While a given bed may have been drip irrigated, amended with compost, or fenced, an adjacent bed may have been hand irrigated, unamended, and unfenced. Several farms maximized space by placing in-ground beds around the edges of raised beds or rows; these "adjacent" beds were usually managed differently because different crops were grown in them. This heterogeneity in management practices was most pronounced among less well-resourced farms and farms distributed across multiple noncontiguous properties, which often differed in layout, infrastructure, use patterns, and surrounding environmental conditions.

Because many growers relied on donated, repurposed, or low-cost materials, management decisions were often opportunistic and based on what was available when practices were implemented. For example, one farm primarily relied on municipal compost but reported a one-time application of untreated manure to a subset of beds after receiving a donation from a local hobby farm.

Grower Food Safety Concerns

Approximately 40% of growers expressed concern about heavy metal contamination, but concern about microbial hazards was limited to a small subset of farms, primarily those with personnel who had received microbial food safety training. These concerns often translated into management actions. Concerns about legacy contaminants led farms to adopt mitigation strategies such as removing and replacing contaminated soil, growing in raised beds or rows, and using soil barriers. The presence and intensity of concern about heavy metal contamination varied by city and were greatest in cities with industrial legacies and where municipal policies sometimes required soil testing and mitigation; these were largely concentrated in the Northeast. For example, all farms in City H, a Northeastern Rust Belt city with regulations governing urban agriculture on contaminated soils, expressed concern about heavy metal contamination and had implemented mitigation measures. In contrast, no growers in City F expressed concern about chemical contamination, despite several farms being located near automotive shops, highways, railways, or former junkyard sites.

Concern about microbial hazards was largely confined to growers with prior food safety training (Table 6). Relatively few growers expressed concerns about microbial hazards, although most had handwashing and bathroom facilities on-site. These facilities ranged from simple improvised stations consisting of a water container and soap to permanent sinks and bathrooms located in packinghouses, farm offices, or other affiliated buildings. Some farms also used facilities in nearby buildings not owned or operated by the farm, including

Table 6. Short Description of Domestic Animal Presence On Site, and Food Safety Training Attended by Growers

	Domestic Animals Present On-site (% of farms) [a]						Food Safety Training (% of farms) [b]			
							Pre-Harvest			Food Handling and Processing (e.g., ServeSafe)
Region (No. of farms)	Bees	Cats	Chickens	Dogs	Ducks	Rabbits	GAPs	PSA	Total	
Northeast (18)	28	11	17	17	6	0	7	0	11	0
Mid-Atlantic (11)	27	45	45	18	9	9	27	0	36	36
Southeast (14)	21	36	29	14	7	7	14	21	36	14
Overall (43)	26	28	28	16	7	5	14	7	26	14

[a] One Mid-Atlantic farm kept pigs.

[b] Not all growers knew or specified the type of produce safety training they received. Food handling and processing training includes ServSafe and USDA Hazard Analysis and Critical Control Point.

neighboring homes, parks, libraries, and office complexes. Two Northeastern farms, consisting of multiple noncontiguous parcels, had handwashing and bathroom facilities at only one parcel. Another farm lacked handwashing facilities but planned to install them by the start of the 2021 growing season. Due to the ongoing COVID-19 outbreak at the time of sampling, almost all farms had ample hand sanitizer on-site.

Structural Constraints

Infrastructure such as packinghouses, fencing, and farm offices varied considerably between farms and reflected available resources, community support, and the security of land access. Insecure land tenure resulting from short-term leases or informal agreements with property owners was common and appeared to limit growers' willingness or ability to invest in infrastructure, soil remediation, or other improvements. Several growers specifically cited concerns about losing access to the property before reaping the benefits of these investments. One farm exemplified this; after six years of renting land from a church and making substantial site improvements, the grower was evicted when church leadership decided to establish its own farm. The eviction resulted in significant financial hardship and a prolonged legal dispute before the grower was able to rebuild at a new location.

Discussion

Variation in management practices within farms created distinct hazard profiles within individual fields and beds, complicating risk management. Past studies have linked management practices to increased or decreased odds of preharvest contamination on commercial farms (Devarajan et al., 2023; D. Weller et al., 2015). The use of spray irrigation has been associated with an elevated risk of contamination, while drip irrigation has a lower risk (Devarajan et al., 2023). Studies have also linked on-farm pathogen prevalence to landscape structure on and around farms, and to wildlife and domestic animal intrusion into fields (Devarajan et al., 2023; D. L. Weller et al., 2022). While many of these studies were conducted on large, commercial farms and focused on practices common to these operations, several practices unique to UFs, including the use of roof-harvested rainwater, have also been linked to elevated contamination risks (Hamilton et al., 2018; Mendez et al., 2011). Indeed, several produce-associated outbreaks have been putatively linked to some of these practices or to animal intrusion (Gelting et al., 2015; Kangas et al., 2008; Osborn et al., 2024).

In the present study, all urban growers used at least one practice considered higher risk (Devarajan et al., 2023), but these practices were not applied uniformly across farms or fields. Instead, practices associated with differing levels of risk were often used concurrently within adjacent, and even the same, beds, and frequently changed throughout the growing season in response to crop rotation and resource availability. Similarly, many farms used whatever water source was closest to a given field for irrigation, with almost all farms relying on two or more water sources. As a result, hazard profiles became spatially and temporally heterogeneous, creating conditions in which some beds, or even portions of individual beds, may have a higher or lower risk of contamination than others. Because GAPs are easier to implement when practices are applied uniformly across a defined production unit, this variability, combined with donated inputs of uncertain provenance, may make both compliance and risk management challenging. Furthermore, several characteristics common to urban farms, including high worker turnover, reliance on volunteers, the prevalence of community gardens and food forests, use of farms as unfenced community spaces, and intentional integration of livestock for fertilization and pest management, may further complicate implementation of GAPs recommendations related to worker hygiene and animal intrusion.

Variation in contamination risk was not driven solely by management practices. Growers in this study reported cultivating more than 190 crops and crop varieties, often comingled within individual beds, and crops differ in their susceptibility to both microbial contamination and chemical uptake. For example, crops where the edible portion directly contacts the soil (e.g., melon, carrots) may be more likely to become contaminated than crops that

don't (e.g., peppers). Plant physiology and crop-specific management practices may also influence bacterial transfer from environmental sources to crops, as well as bacterial attachment to and survival on plant surfaces and in soils (Islam et al., 2005; Park et al., 2022). Risks to human health may vary according to both how crops are consumed and their propensity to accumulate contaminants. Crops that are typically cooked, such as potatoes, may pose lower direct risks from microbial contamination, although they can still contribute to post-harvest cross-contamination. Similarly, crops differ in their ability to take up and translocate chemical contaminants from soil (H. Zhou et al., 2016). As a result, contamination risk is not only spatially and temporally heterogeneous, but also crop-dependent, with exposure pathways and potential health impacts varying among commodities even when they are grown in the same bed using the same practices.

These findings do not suggest that UFs are uniquely heterogeneous relative to large-scale commercial farms. Prior studies have consistently demonstrated spatial variation in microbial contamination risks on commercial farms (e.g., Harrand et al., 2020; D. Weller et al., 2016). However, the variability observed here often operated at finer spatial and temporal scales. For example, practices in the present study frequently differed within individual beds, whereas previous work on large-scale commercial farms primarily identified variation at the farm or field level (D. Weller et al., 2015). These findings suggest that the scale at which risk is typically assessed and managed may not align with the fine-scale heterogeneity present on many UFs. When hazard-relevant practices vary within beds and change over time in response to shifting resource availability, whole-farm or whole-field approaches may obscure meaningful differences in contamination risk. Adapting produce safety guidance to account for bed-level variability and improving growers' ability to identify combinations of practices associated with elevated contamination risk may support more effective implementation of GAPs.

Grower concerns, which centered on chemical, not microbial hazards, were shaped by regulatory visibility and land history. This study and prior studies have shown that UFs exist within an urban landscape of overlapping historical and concurrent land use (Romero & Harris, 2019; Valley & Wittman, 2019). Many farms occupied former industrial, commercial, or mixed-use sites and bordered a diverse range of neighboring land uses, conditions that have been associated with both legacy soil contaminants and ongoing chemical exposures from surrounding environments (A. A. Paltseva et al., 2022). While past studies have identified several potential sources of these contaminants (Gamble et al., 2018; Kaiser et al., 2015; Laidlaw & Filippelli, 2008; A. Paltseva et al., 2018), additional research is needed to place the human health risks associated with these contaminants in the context of the broader health and societal benefits provided by UF. This is particularly important because contaminant accumulation in edible tissues varies among crops and is influenced by soil conditions, contaminant characteristics, and management practices. On the other hand, overall human health impacts are likely driven by cumulative exposures from multiple dietary and environmental sources.

Historical land use, combined with local regulations, appears to have influenced growers' knowledge and priorities regarding on-farm hazards. Many growers expressed concern about the food safety implications of legacy chemical contamination, whereas only a small subset expressed concern about microbial hazards. Similar patterns have been reported in studies of urban growers in Atlanta and Baltimore, where concerns about chemical contamination predominated (Harms et al., 2013; Kim et al., 2014). This imbalance may reflect differences in the visibility of chemical and microbial hazards within regulatory, educational, and outreach frameworks (Santo et al., 2021). Most UFs are exempt from federal produce safety regulations because annual sales fall below the US$25,000 threshold (Pressman et al., 2016; Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption Relating to Agricultural Water, 2024). In contrast, many growers are subject to local policies addressing heavy metal contamination in urban soils (Halvey et al., 2021; Lupolt et

al., 2022), and extensive guidance on mitigating chemical hazards, particularly lead, are available through municipal governments, NGOs, and extension services. This emphasis may help explain why lead was the primary heavy metal of concern in both the present and previous UF studies (Balotin et al., 2020; Kim et al., 2014). More broadly, research on risk perception suggests that hazards receiving sustained institutional attention are more likely to be perceived as important (Kasperson et al., 1988; Zhu & Liu, 2021), potentially shaping how growers prioritize risk management. Indeed, access to information appears to have shaped how growers understood and responded to on-farm food safety hazards. Growers with institutional support or strong community ties were better able to identify and mitigate hazards associated with past land uses. Awareness of land history and surrounding land uses contributed to concern about contaminants and shaped mitigation strategies, including soil removal, raised-bed construction, and installation of soil barriers. However, consistent with prior research, many growers were unaware of established best management practices for managing chemical hazards, and several mitigation strategies reported here have been shown to be ineffective at or of limited value for reducing chemical exposures (Kim et al., 2014; A. A. Paltseva et al., 2022).

Despite widespread concern about heavy metal contamination, many growers lacked the resources needed to assess or address these hazards. Several growers in the present study reported concerns about heavy metals but were unable to afford testing, a barrier also documented among urban growers in Atlanta and Baltimore (Balotin et al., 2020; Kim et al., 2014; Santo et al., 2021). One farm removed approximately half of its land from cultivation after preliminary test results suggested contamination, but lacked funding for the additional testing needed to precisely delineate affected areas. Portions of the site were subsequently repurposed (e.g., storage, parking). These findings indicate that contamination risk management on UFs is influenced as much by social and institutional factors as by environmental conditions. Access to information, technical support, and affordable testing appeared to play important roles in determining whether growers recognized potential hazards and were able to respond effectively.

Structural constraints, including insecure land tenure, may limit food safety capacity. Many farms operated as nonprofits and, consistent with findings from a national grower survey, farming was often not the sole source of income even among for-profit operations (Pressman et al., 2016). Nearly all farms relied heavily on volunteers or part-time workers, contributing to high turnover and variability in experience and training. In several cases, farm managers were AmeriCorps members, community volunteers, or staff embedded within larger organizations (e.g., churches or hospitals) who had limited or no prior agricultural training. Similar organizational structures have been described in other studies of urban farms (Gilbert et al., 2020; Kelly, 2023; Pressman et al., 2016; Rangarajan & Riordan, 2019). High staff and volunteer turnover, combined with limited resources, may also help explain why relatively few farms in the present study had personnel who had received formal pre-harvest food safety training. Similar barriers, including capital constraints, limited time, and uncertainty about where to seek training, have been reported among urban growers in New York City (Cohen & Reynolds, 2015). These findings suggest that the volunteer-based and frequently changing workforce observed on many UFs may not align well with conventional approaches to implementing GAPs, which often rely on consistent worker training, supervision, and documentation. New training and education approaches designed specifically for infrequent, temporary, volunteer, or youth workers may therefore be needed.

Land insecurity and limited land access represent particularly important constraints (Pressman et al., 2016; Santo et al., 2021). While not always explicitly framed as a food safety issue by growers, insecure tenure discouraged long-term infrastructure investment, including improvements that might have improved on-farm food safety outcomes (e.g., fencing, handwashing facilities; Pressman et al., 2016). In Baltimore, 39% of urban growers were on private land owned by someone else, and 49% were on city land; 29% of growers were only some-

what confident and 6% doubted that their operation had sufficiently secure tenure to remain a farm in the future (Santo et al., 2021). Overall, these findings suggest that food safety on UFs is not solely a technical or knowledge issue. Insecure tenure, rotating staff, limited infrastructure, multifunctional missions, and community-facing design all shape what practices can be consistently implemented. Ensuring food safety in urban agriculture therefore requires attention not only to technical guidance but also to the structural conditions that shape whether and how such guidance can be implemented (Cohen & Reynolds, 2015).

Co-managing food safety alongside sustainability and community goals poses challenges for UFs. Consistent with past work (Pressman et al., 2016), the farms surveyed here generally balanced food production with other aims. Indeed, UFs frequently pursued multiple objectives simultaneously, including soil remediation, ecological restoration, waste diversion, community engagement, food security, and education (Pressman et al., 2016; Santo et al., 2021). Unlike conventional production systems, these objectives were frequently pursued within the same physical space by a small number of staff and volunteers. Consequently, management decisions often involved balancing competing priorities, and practices intended to advance one objective or reduce one risk could create new challenges in another area. Raised beds, soil amendment, and soil barriers may reduce crop contact with and uptake of soil chemical contaminants (Barbillon et al., 2023; Binns et al., 2004; Moskal & Berthrong, 2018). However, implementing these strategies often requires importing soils, amendments, or construction materials. When these inputs are recycled or donated, their provenance and prior use may be unknown, creating opportunities for the introduction of chemical or microbial hazards. For example, many farms obtained leaves, weeds, and other organic materials for composting and top-dressing from neighbors, local organizations, and municipal programs without knowledge of their source histories, despite evidence that historic use of lead-arsenate pesticides and lead paint can contribute to persistent lead contamination in urban and farm environments (Turner & Lewis, 2018; Wolz et al., 2003). Similarly, recycled treated wood used in raised beds has been identified as a potential contamination source (Kessler, 2013) and was used by several of the farms participating here. The use of compost, manure, and food waste may support soil health and circular economy goals, but when information on source, treatment status, and storage conditions is unavailable, the potential for introducing chemical and microbial hazards may be difficult to assess (Yang et al., 2024). Spatial constraints further shaped these trade-offs. Because many UFs operated on small or fragmented parcels, opportunities to spatially separate potentially conflicting activities (e.g., composting, production, community use) or implement spatially explicit food safety practices (e.g., non-crop buffers) were limited. Collectively, these findings suggest that, as seen among conventional farms (Baur, 2020), food safety on UFs cannot be considered independently of the broader social, environmental, and community objectives that shape management decisions. Practices adopted to support sustainability, remediation, food access, or ecological stewardship may also influence contamination pathways, highlighting the need to evaluate risks and benefits across multiple domains simultaneously.

UFs are often characterized by small production areas, fragmented layouts, and the presence of non-crop vegetation associated with food forests, hedgerows, windbreaks, and open-space programs. Together, these features may increase opportunities for interaction between crops, domestic animals, and wildlife relative to conventional farms (Ries et al., 2004; Tscharntke et al., 2005). Although domestic and wild animals have been repeatedly identified as vectors for pathogen introduction and dispersal (Berry et al., 2015; Jay et al., 2007; Loewald et al., 2024), most growers in the present study were concerned about crop loss rather than food safety, a pattern also reported in Baltimore (Kim et al., 2014). Some farms embraced wildlife presence as part of their urban ecology, documenting these challenges through signs such as "Dear rats, please leave our squash alone" and social media posts noting that "The invasion of the critters continues… ." At the same time, growers recognized that animals provided valuable services, including pest

and weed control, soil fertility, and other ecosystem functions documented elsewhere (Jones et al., 2019; Karp et al., 2016; Olimpi et al., 2022). Similar tensions existed with respect to people. Prior research has identified humans as potential vectors for pathogen introduction (Dato et al., 2003; Shaw et al., 2015). However, because many farms prioritized community access as part of their broader mission, restricting human and animal entry was often impractical, if not contrary to farm values. As a result, approaches to managing access varied considerably across sites, ranging from fully fenced farms to partially fenced or entirely open operations.

In practice, growers were managing overlapping risks and aims operating across chemical, microbial, ecological, and social domains. Management decisions often reflected trade-offs among sustainability, affordability, labor availability, regulatory requirements, public service commitments, and community expectations, with food safety concerns often secondary to these more immediate priorities. While similar challenges of co-managing competing objectives have been documented in conventional agriculture (Adalja et al., 2023; Baur, 2020; Karp et al., 2016; Olimpi et al., 2019), UFs frequently navigated these goals within the context of insecure tenure, limited infrastructure, and rotating labor, as discussed above. Thus, UF food safety cannot be understood solely as a matter of regulatory compliance but must instead be considered within the broader environmental, organizational, and resource constraints that shape farm management decisions. Supporting food safety in urban agriculture will require training, guidance, and support that recognize these trade-offs and help growers co-manage competing objectives.

Limitations

This study relied on snowball sampling and voluntary participation, which may limit the representativeness of the sample. Participating farms were located in the Northeast, Mid-Atlantic, and Southeast USA; findings may not reflect practices in other regions, including the West Coast. Data were based on interviews and site observations conducted during a single growing season and represent a cross-sectional snapshot rather than longitudinal trends. Practices were self-reported and may not fully capture all management decisions, particularly for farms with informal or diffuse management structures. Accordingly, findings should be interpreted as illustrative of variability patterns rather than being representative of urban growers across the USA.

Conclusion

UFs in this study exhibited substantial variation in land-use history, management practices, infrastructure, workforce structure, and organizational mission. Hazard-relevant practices often varied not only between farms but also within individual farms, fields, and beds, creating fine-scale differences in potential contamination pathways. Growers' perceptions and management of hazards were influenced by local regulations, access to information, resource availability, and historical land use, while food safety was frequently balanced against, and secondary to, broader goals. Growers demonstrated resourcefulness in navigating structural challenges, such as insecure land tenure, limited infrastructure, and reliance on volunteers, through adaptive practices like raised beds, soil barriers, and creative use of materials. However, these same conditions constrained the consistent implementation of food safety practices and highlighted the limitations of conventional frameworks designed for commercial, rural farms. Supporting safe food production in urban agriculture will require policy, technical assistance, and training models that reflect the unique operational realities of these systems, addressing not only knowledge gaps but the structural barriers that limit growers' ability to access and act on that knowledge. Together, these findings highlight the diversity of urban farming systems and the complexity of managing food safety within multifunctional UF landscapes. Supporting food safety in urban agriculture will require guidance, training, and technical assistance that account for fine-scale variability in hazards, competing objectives, and resource constraints that characterize many urban farms.

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Women as catalysts of rural transformation: A systematic review of barriers, opportunities, and policies in the Global South

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Abstract

Women play a crucial role in rural transformation in developing countries, but they face significant socio-economic, cultural, and structural barriers that hinder their full participation. Despite their contributions to agriculture and rural development, systemic inequities in access to resources, education, and decision making limit their potential as agents of change. Our research aims to analyze the challenges women face in rural transformation, identify opportunities for their empowerment, and propose actionable policy recommendations for gender-inclusive rural development. A systematic literature review was conducted using the Scopus and Web of Science databases, focusing on peer-

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reviewed articles published between 2015 and 2025. Using the PRISMA framework, 166 studies were selected from 499 studies across South Asia, sub-Saharan Africa, and Latin America. These major developing regions have rural populations reliant on agriculture, in which women play crucial roles but face gender barriers. Women face obstacles such as limited access to land, technology, credit, and markets, hindering their full contribution to sustainable food systems. Enabling factors such as capacity building, digital literacy, cooperative farming, and gender-transformative policies enhance women's agency in food production. Empowering women through training, inclusive financing, and land rights improves productivity, food security, and sustainability. The findings highlight the need for inclusive rural policies, interdisciplinary collaboration, and gender-sensitive infrastructure to support women in agriculture. Integrating women into rural and food strategies is key to long-term sustainability. Future research should evaluate the impact and scalability of gender-inclusive policies in diverse rural contexts.

Keywords
rural transformation, women's empowerment, gender inequality, developing countries

Introduction

Rural transformation represents one of the most consequential pathways for reducing poverty in the Global South, offering the potential to shift millions of households from subsistence agriculture toward diversified, commercially integrated livelihoods. Transformation involves structural change through which rural economies transition to diversified production, commercialization, and non-farm employment (Huang & Shi, 2021; Wang et al., 2023). Underpinning this transformation are three interconnected dimensions with significant gender implications: (1) agricultural changes, including the adoption of high-value crops, mechanization, and sustainable practices; (2) employment diversification spanning on-farm and off-farm wage labor, and non-farm enterprises; and (3) institutional realignments encompassing land tenure reforms, market integration, and policy interventions. High-value agriculture—including horticulture, livestock, fisheries, and plantation agriculture—plays a particularly vital role in raising rural incomes (Rachmawati et al., 2025; Sudaryanto et al., 2023; Wang, Chen et al., 2025), while also supporting long-term sustainability through soil health, pest control, climate resilience, and dietary diversity (Food and Agriculture Organization of the United Nations [FAO], 2023).

Despite the transformative potential of these processes, their benefits are not uniformly distributed. Women, who constitute the majority of the rural agricultural workforce across South Asia, sub-Saharan Africa, and Latin America, are systematically excluded from the gains of rural transformation. In sub-Saharan Africa, women comprise approximately 60% of the farm workforce (Meinzen-Dick et al., 2019), and in South Asia, around 70% of women work in agriculture (FAO., 2023), yet their contributions remain undercounted, underpaid, and undervalued. This paper argues that understanding and addressing the gendered dimensions of rural transformation is both necessary and urgent: existing policies have proved insufficient in bridging structural inequalities, and a more targeted analytical framework is needed to enhance women's agency and improve food security and economic well-being (Kumar et al., 2018). This systematic review directly responds to that gap.

Women are not peripheral actors in rural transformation—they are its frontline managers. As primary stewards of biodiversity and soil health, women farmers play an indispensable role in the sustainability of agrifood systems, yet they consistently lack access to the resources, inputs, and markets necessary to fully realize their productive potential (FAO, 2023). Evidence from across the Global South illustrates both the scale of women's contributions and the impact of targeted interventions that recognize them. In India, women's horticulture groups have boosted yields and improved income and product quality through pluralistic extension interventions (Ramya et al., 2026); in Kenya, connecting smallholder women with certified seeds and markets improved productivity and reduced losses by 30% (Njuki et al., 2025); in Ethiopia, certifying land rights for over two million women enhanced agricultural productivity (Bezabih

et al., 2016); and in Bangladesh, training women in vegetable gardening improved both nutritional outcomes and women's control over household income (Rola-Rubzen et al., 2024). In Pakistan, women's education has driven the shift toward high-value crops in regions like Punjab and Khyber Pakhtunkhwa, and rising female labor force participation has been a significant driver of rural transformation, though gains in female off-farm employment remain regionally uneven (Naz et al., 2025), while in China, the Rural Revitalization Strategy's poverty-prevention goals depend on women's empowerment and social capital as a key mechanism, with women's agency significantly reducing household poverty in previously poverty-stricken rural counties (Wang, Gu et al., 2025). These examples underscore that women's full participation in rural transformation is not only an equity imperative but a prerequisite for sustainable agricultural development.

Despite their central roles, women in rural economies face deeply entrenched and intersecting challenges that constrain their participation in and benefit from rural transformation. Structurally, capitalist patriarchy and mechanization reinforce land inequality and limit women's access to productive resources (Njuki et al., 2025). Women in the Global South routinely lack formal land tenure, access to credit, and opportunities for market participation, while cultural and social norms, including discriminatory gender roles, unequal household labor burdens, and restricted mobility, further narrow their economic agency (Doss et al., 2019; Singh et al., 2023). In West Sumatra, women balance heavy household duties with agricultural labor (Mutiara et al., 2022); in Pakistan, cultural constraints confine many women to indoor economic activities (Akram, 2018); and in Northern Mozambique, only 30% of women control agricultural plots (de Brauw, 2015).

Gender gaps in rural organizations further undermine women's influence over decision making, rendering their contributions invisible in both policy and practice (Hejase et al., 2020). Challenges related to infrastructure, including inadequate irrigation systems, inequitable access to clean water, and limited market connectivity, compound these gendered disadvantages, highlighting the urgent need for government support and gender-sensitive policy design. Rural women are also disproportionately vulnerable to the effects of climate change: female-headed households lose 8% more of their income to heat stress and 3% more to floods than male-headed households, amounting to US$37 billion and US$16 billion in lost income annually across low- and middle-income countries—a gap projected to widen to 34% under a further 1°C of warming (FAO, 2024). This vulnerability stems from women's greater dependence on climate-sensitive natural resources and agriculture, restricted mobility and access to information, and unequal access to land, credit, and decision-making power (FAO, 2024); yet their critical roles in climate change mitigation and food security remain overlooked in mainstream policy frameworks (Asih, 2021; Ngo & Tran, 2024). These overlapping obstacles create a cycle of marginalization that limits women's economic potential and perpetuates their structural exclusion from rural transformation processes (Rola-Rubzen et al., 2024; Slavchevska et al., 2016).

Notwithstanding these challenges, emerging evidence identifies significant opportunities for advancing women's empowerment within rural transformation processes. Collective action has proven particularly effective: where women organize through cooperatives, self-help groups, and community-based organizations, they are better positioned to challenge patriarchal norms, access shared resources, and shift decision-making power toward the commercial sphere— increasing household income and resilience in the process (Ngo & Tran, 2024; Prihatiningtyastuti, 2020). Technological adoption and infrastructure investment also open new pathways for women's economic participation, provided that access is equitable and gender-responsive. Digital finance initiatives have shown promise in diversifying income sources for rural households (Huang & Rozelle, 2018), and future research into communal water governance may further mitigate the impact of climate-induced scarcity on smallholder women's productivity. At the institutional level, land tenure reform and inclusive policy design represent critical levers: when women hold formal land rights, their productivity, bargaining power, and investment behavior

improve significantly (Diiro et al., 2018). Gender-sensitive policies that ensure women's inclusion in policy processes, rather than treating empowerment as an add-on, are essential for unlocking the full productive potential of rural women and making rural transformation genuinely inclusive (Doss et al., 2019; Kumar et al., 2018). While agricultural entrepreneurship empowers rural women, significant barriers remain, however, including policy environments that inadequately support women's land rights, credit access, and market participation, as well as deeply rooted social and structural obstacles such as discriminatory norms, unequal workload burdens, and restricted mobility that limit opportunities for women's engagement in rural economic activities. Gender gaps in rural organizations continue to undermine women's contributions to development, with negative consequences for both household welfare and the broader rural economy. Initiatives must therefore address these systemic imbalances and explicitly recognize the multifaceted challenges faced by rural women (Singh et al., 2023).

Despite a growing body of research on gender and rural development, the existing literature remains fragmented, with few studies offering a systematic analysis of how the multiple dimensions of rural transformation—agricultural change, employment diversification, and institutional realignment—simultaneously shape barriers and opportunities for women. Identifying barriers alone has proved insufficient; what is needed is an integrated framework that examines these processes together and identifies the conditions through which transformation genuinely empowers women. This paper addresses that gap through a systematic review of relevant studies conducted in accordance with PRISMA guidelines, using the Women's Empowerment in Agriculture Index (WEAI) and the Rural Women's Empowerment framework as theoretical anchors. The WEAI, developed in 2012 by the International Food Policy Research Institute (IFPRI), the Oxford Poverty and Human Development Initiative (OPHI), and the Feed the Future program, led by the United States Agency for International Development (USAID), measures agricultural empowerment across five dimensions (productivity, resources, income, leadership and time) and gender parity (Quisumbing et al., 2023). Section 2 outlines this theoretical framework. Section 3 details the systematic methodology. Section 4 presents findings across three dimensions—well-being, employment, and empowerment—analyzing barriers, opportunities, and policies. Section 5 discusses policy implications and cross-cutting themes. Section 6 addresses limitations and future research directions. By providing a structured analysis, this review aims to offer clear, evidence-based guidance for researchers, policymakers, and development practitioners seeking to make rural transformation work for women.

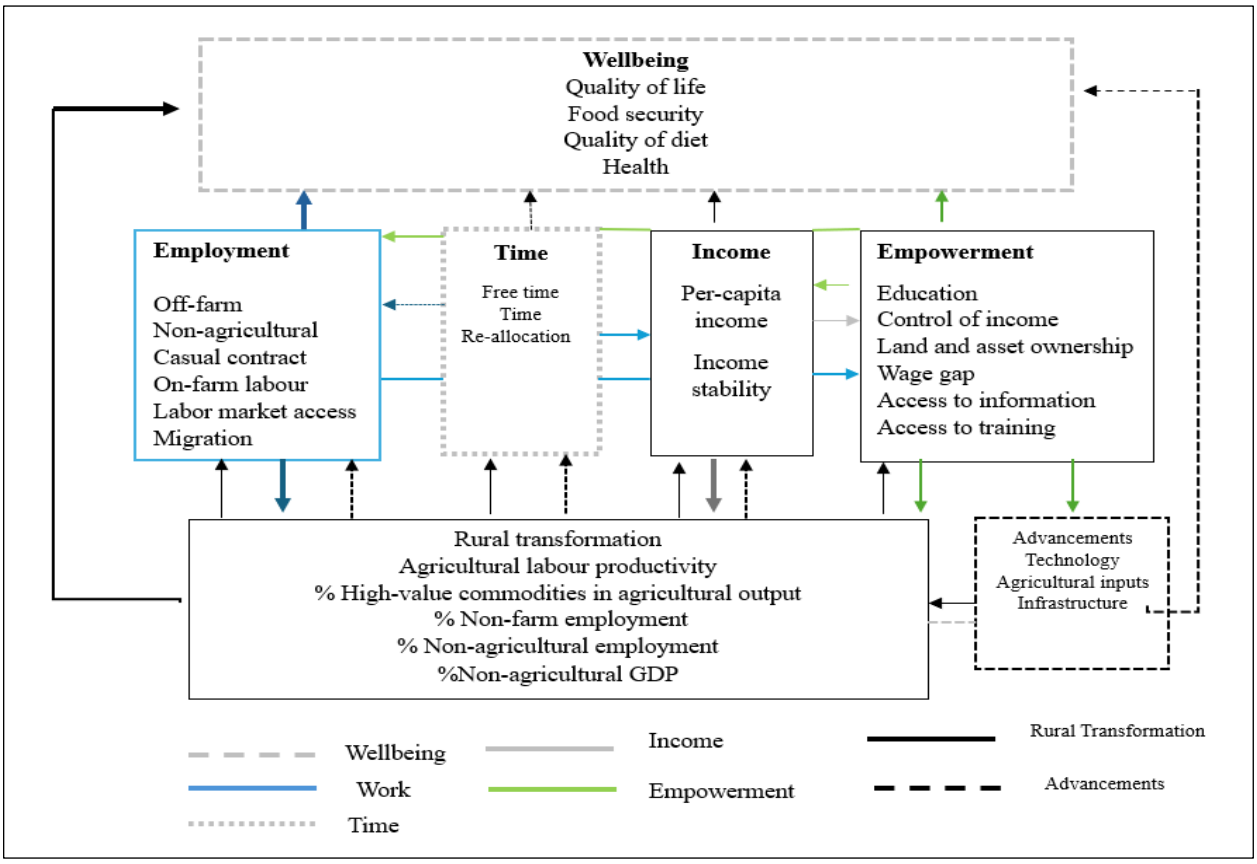
Theoretical Framework

Women in South Africa, sub-Saharan Africa, and Latin America exceed the global average in agri-food sector involvement, with over two-thirds participation (FAO, 2023), underscoring women's crucial agricultural role and potential for productivity. The focus on women as economic drivers gained significant momentum following the World Bank' report, *Gender Equality and Development* (2012). That foundational report established a clear macroeconomic case for gender parity. Earlier estimates from FAO suggested that closing the gender gap in access to agricultural resources could boost total agricultural output in developing countries by 20 to 30 percent (2011). Recognizing women's crucial role in global food systems, FAO declared 2026 the International Year of the Woman Farmer (2026), responding to 2023 data urging gender-transforming policies to empower women in the agri-food sector. Research has found that productivity, food security, nutrition, and climate resilience improve when women have decision-making autonomy in agricultural production and household resource allocation (Dar & Waza, 2026; Dessie, 2025; Ghosh et al., 2021; Mataka et al., 2023). Our research uses the Rural Women's Empowerment framework (Rola-Rubzen et al., 2023) to analyze these dynamics. This framework uses a multidimensional lens to examine how rural transformations, such as technological adoption and market integration, affect women's well-being through employment, time allocation, income, and empowerment. Technology, such as mechanized farming tools and high-value inputs, boosts women's labor

productivity. Infrastructure improvements, such as electrification and clean water access, reduce the time women spend on chores, enabling them to focus on income activities or training. Digital technologies connect rural women to market resources, providing real-time access to information and financial services (Figure 1). The Rural Women's Empowerment framework also assesses how institutional shifts can hinder or facilitate women's agency in sustainable rural development by contextualizing barriers, such as time poverty and patriarchal norms.

Women's role in agriculture is vital for food security in the Global South, which is increasingly transitioning from subsistence farming toward active stewardship of sustainable agricultural systems, encompassing soil health management, biodiversity conservation, and climate-adaptive practices. Women who adopt such sustainable practices often challenge prevailing gender roles by innovating within their productive environments, thereby forging important links between economic growth and ecological resilience (Vuciterna et al., 2024). Sarita Devi's organic farm in India exemplifies how women's agricultural leadership can catalyze broader community change (Chinmaya Organization for Rural Development, 2023). Operating as a collectively managed enterprise, the farm integrates high-value organic production with community outreach, providing neighboring women farmers with training, market linkages, and organizational support—demonstrating that women-led agricultural enterprises can function as scalable models of rural transformation. Women agricultural entrepreneurs of this kind simultaneously boost household incomes and advance sustainable land management practices, offering replicable pathways for improved

Figure 1. Theoretical Framework of Rural Women's Empowerment



Source: Rola-Ruben et al., 2023. Reproduced under CC BY-NC-ND 4.0 license,

nutrition and economic resilience in rural communities (van Gelderen, 2016).

Women allocate income to family well-being, including food, education, and healthcare. Investments in gender equality create jobs and promote development. Structural and socio-cultural constraints, such as limited land ownership, lack of formal credit, and traditional norms hinder progress (Kegnide et al., 2024). Addressing inequality requires expanding employment opportunities and access to resources for women (Dula, 2019). Sustaining and scaling women's entrepreneurship in rural communities require the convergence of three enabling conditions: access to financial capital, targeted skills and business training, and a supportive institutional and policy environment that reduces structural barriers to market participation. When these conditions are present, rural women are better positioned to establish and grow enterprises that not only enhance household economic security but also contribute to broader rural economic development.

Women face systemic barriers such as limited access to finance, land, and education, which constrains their entrepreneurial potential. Sociocultural factors further compound these inequalities by restricting opportunities for women's economic participation (Kegnide et al., 2024). Addressing financial exclusion requires tailored financial products designed around women's realities, such as micro-loans with flexible repayment schedules aligned with harvest cycles, or credit models that leverage social collateral rather than requiring formal assets. Complementing these financial mechanisms, gender-sensitive policies are essential to dismantle structural barriers and create an enabling environment in which women entrepreneurs can fully participate in agricultural and rural development (Kowalewska, 2023). Employment diversification and rural-to-urban labor migration for seasonal work provides additional income streams, enhancing economic stability (Che et al., 2015).

Access to extension services and development activities helps equip women for rural development. Extension services offer technical training in horticulture and seed management, as well as offering digital tools for market data and financial literacy. Development activities include, for example, land rights certification in Ethiopia, a government-led program that issues land-holding certificates to rural households, including women, formally recognizing their rights to use and transfer land. Women's access has been shown to increase women's tenure security and bargaining power (Melesse et al., 2018). These interventions connect rural women with necessary resources. Cultural norms must also be considered, as prioritizing household duties over income-generating activities can hinder women's empowerment. Cultural factors and resource availability affect women's participation in income-generating activities (Wenda & Fon, 2021).

Empowerment indicators such as income, resource control, and decision-making power reflect program success. Empowerment activities have been shown to increase women's income and financial independence (Alkire et al., 2013). Women's increased decision-making power from these initiatives reflects broader economic and social shifts, as women gain greater control over resources, ultimately contributing to the well-being of rural communities.

Methodology

Our search strategy, developed by a lecturer from the University of Indonesia, Francisia Saveria Sika Ery Seda (Professor of Sociology, Faculty of Social and Political Sciences, specializing in development studies and social exclusion), Mia Siscawati (lecturer, Gender Studies Graduate Program and Department of Anthropology, specializing in gender and development policy), and Hariati Sinaga, (lecturer, Gender Studies Graduate Program, School of Strategic and Global Studies, specializing in feminist political economy and gender-labor relations), was designed to locate relevant literature for a systematic review. The search used the following terms: rural development, rural transformation, women's and rural development, women in rural areas and institutions, policy and investments (IPIs), opportunities and barriers for rural women, structural transformation in agriculture, off-farm employment, gender equality, gender inclusiveness, impacts, disadvantages, problems, constraints, strengths, and advantages. The literature search was conducted from January to March

2025. We used Boolean operators 'AND,' 'OR,' and 'NOT' to refine our search results.

The search aimed to create a comprehensive literature map of rural transformation (RT) and its effects on gender across disciplines. The search terms in the Scopus and Web of Science databases included agricultural sciences, multidisciplinary, environmental sciences, women's studies, business, fisheries, forestry, social science, and other relevant areas. From 499 initial Google Scholar records, 225 were excluded based on specific criteria: 34 non–peer-reviewed journals, seven duplicates, 149 records outside of our desired range of years (2015–2025), 58 studies irrelevant to rural transformation or gender inclusivity, 44 in which full texts were inaccessible, 31 records restricted to high-quality, peer-reviewed literature published in journals ranked within the Q1 to Q4 quartiles, 17 non-English papers, 30 without IPI linkages or developing-country focus, and four records lacking abstracts. These exclusions ensured that only high-quality studies were included in the Systematic Literature Review (SLR) framework.

Criteria for Inclusion and Exclusion

Our systematic literature review followed PRISMA guidelines for transparency, reproducibility, and rigor (Moher et al. 2009). Inclusion criteria used a modified PICO(S) framework: Population—women in rural transformation in developing countries; Intervention/Exposure—structural, cultural, economic barriers and opportunities (including IPIs); Comparator—not applicable; Outcomes—impacts on women's empowerment, wellbeing, productivity, and food security; and Study designs—peer-reviewed articles in English 2015–2025, with full-text access and clear links to gender/rural transformation dynamics. Restricting our study to include only English language papers ensured socio-cultural concept interpretation, while the 2015–2025 period captured post-Sustainable Development Goals (SDG) trends.

Extraction, Screening, and Review of Records

The screening process had three stages: (1) removing duplicates and initial screening of 499 records from Scopus and Web of Science, leaving 274 for full evaluation and excluding 225; (2) full-text assessment of 196 articles, excluding 78 for language (including 17 not in English); and (3) confirming eligibility of 184 articles, retaining 166 after excluding 18 misaligned with gender/rural transformation/IPIs. Two authors screened the articles independently, resolving conflicts with a third reviewer. The search used Boolean operators (AND/OR/NOT) with terms like "rural transformation OR rural development AND women OR gender OR empowerment AND barriers OR opportunities OR IPIs". Database searches were conducted from January–March 2025. This process enhances the validity of the study for replication and bias assessment per the PRISMA standard.

Data Extraction

A literature review was conducted to compile indicators related to rural transformation (RT), effects, gender inclusivity, and outcomes. Table 1 presents barriers to women and rural transformation outcomes. The identification method involved assessing the eligibility of full-text articles. Of the 184 full-text papers evaluated, 18 were excluded because they did not address women's roles and institutions, investments, and policies (IPIs) in developing countries. The remaining 166 papers were selected for their relevance to gender, rural transformation, and indigenous experiences (Figure 2). This screening ensured that the papers provided insights into gendered rural transformation.

Quality Appraisal

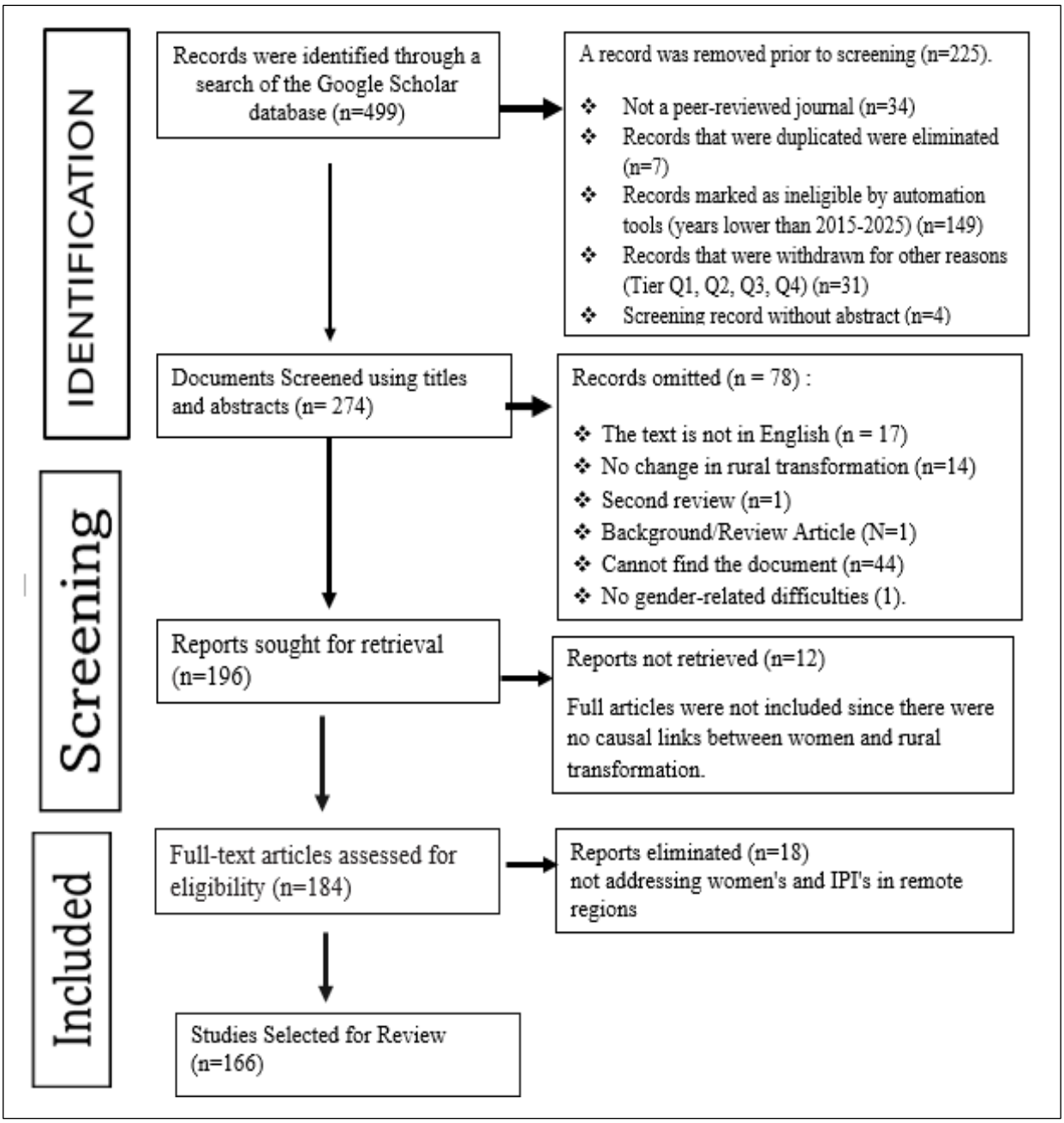
The methodological quality of the studies was evaluated for validity and reliability using PRISMA guidelines. Two reviewers independently appraised each study using the Covidence software, resolving discrepancies through consensus or a third reviewer. The Cochrane Risk of Bias tool, customized for diverse designs, assessed selection, performance, detection, attrition, and reporting bias, rating each as low, high, or unclear risk. Only high-quality evidence was included, retaining studies with a minimum quality score of 70%, and ensuring the final 166 papers provided robust insights into gender dynamics and rural transformation.

Results and Discussion

One hundred sixty-six articles were selected in

order to analyze the role of women in rural transformation in developing countries, organized by year (Figure 3). The first publication year was 2015, with significant growth in scholarly output from 2020 to 2024, surpassing earlier years. Fewer publications in 2018 indicate maturation after the 2015 Sustainable Development Goals and precede intensified research on gender-transformative rural development. Fluctuations in 2023 likely resulted from journal cycles or indexing lags by early 2025, demonstrating the growing focus on women's empowerment in developing nations.

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses



Set of reporting protocols that clearly outlines the steps undertaken in systematic reviews and meta-analyses.
https://www.prisma-statement.org/

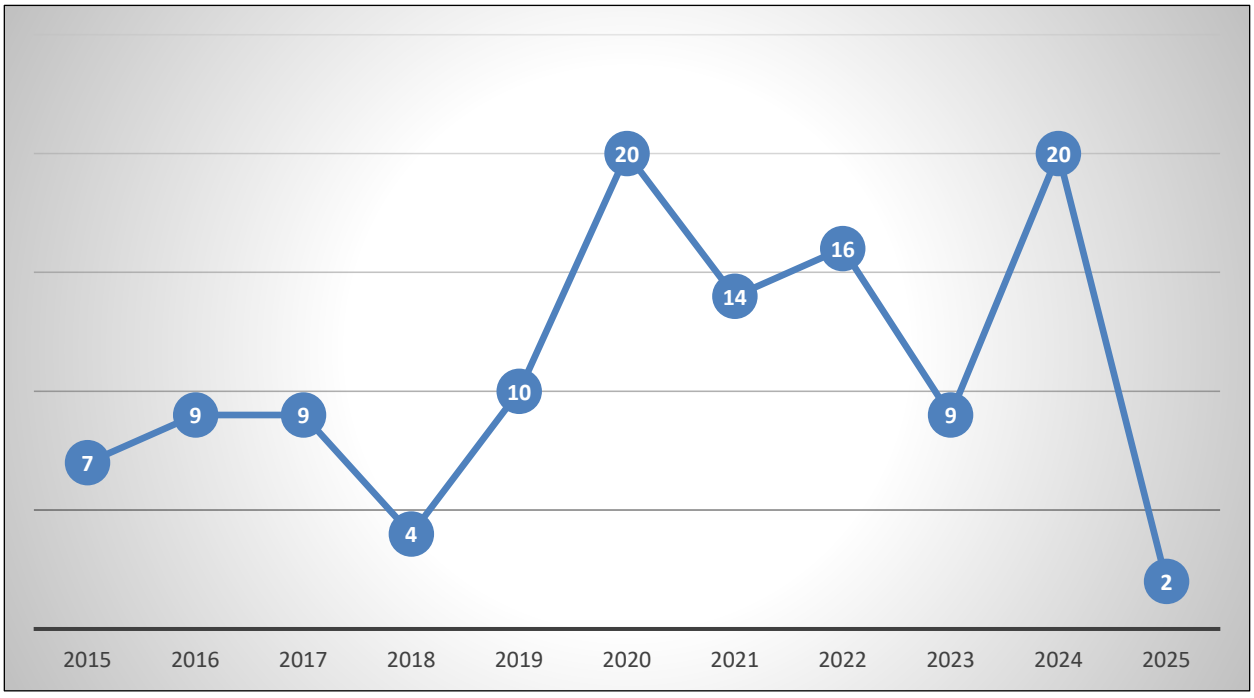
The synthesis of 166 studies shows overall that rural transformation increases women's labor participation in agriculture but often exacerbates inequalities. In South Asia, sub-Saharan Africa, and Latin America, women generally work 10–12 hours daily, balancing domestic and farm tasks. This coincides with a wage gap, women earning 20–30% less than men for similar work in regions such as India and Sub-Saharan Africa (McCarthy & Kilic, 2015). Technological interventions also present contradictions. While labor-saving technologies in Eastern Africa and Bangladesh reduce domestic burdens, evidence from Nepal shows that women's time poverty remains (Ghimire et al., 2024) without changes in gendered labor division. Non-farm sectors, such as Bangladesh's garment industry, offer more income stability, but cultural constraints and safety concerns limit women's access to urban labor markets (Stillman et al., 2020). These findings indicate that the success of rural transformation varies based on how local institutions address patriarchal norms.

Figure 4 shows the geographical distribution of studies across countries based on where they were conducted. Significant contributions from South America, Asia, and sub-Saharan Africa are highlighted. Notably, India (26), Bangladesh (18), Ethiopia (13), and Indonesia (12) have made substantial contributions. In addition, countries such as Nepal and Kenya (9) and Nigeria (8) demonstrate the global reach of this research.

A growing body of literature has linked gender and rural transformation: the 166 studies show the need to reconnect barriers and opportunities to their origins and consequences in agriculture. Barriers that affect women—limited access to land, credit, and technology—lead to lower yields, reduced crop diversity, inefficient use of inputs, and weaker value chain integration, all undermining sustainable food production. For example, without formal land titles —legal documents that prove ownership and enable access to credit and investment—women cannot secure climate-smart loans or make long-term soil-conservation investments, thereby undermining food system sustainability. Conversely, opportunities such as cooperative farming, digital services, and secure property rights enhance women's resource agency, thereby improving farm productivity and food security.

Through a gender-inclusive analytical framework, this paper examines well-being, employment, time allocation, and income as key dimensions

Figure 3. Year That the Studies on Women and Rural Transformation Were Published



through which barriers and opportunities shape women's agricultural outcomes. This paper evaluates how each barrier reduces farm productivity, how each opportunity strengthens value chains, and how policy contributes to building a resilient, equitable agri-food system. This helps keep discussions of women's empowerment grounded in agricultural development and sustainable food production goals.

Women's Wellbeing in Rural Transformation

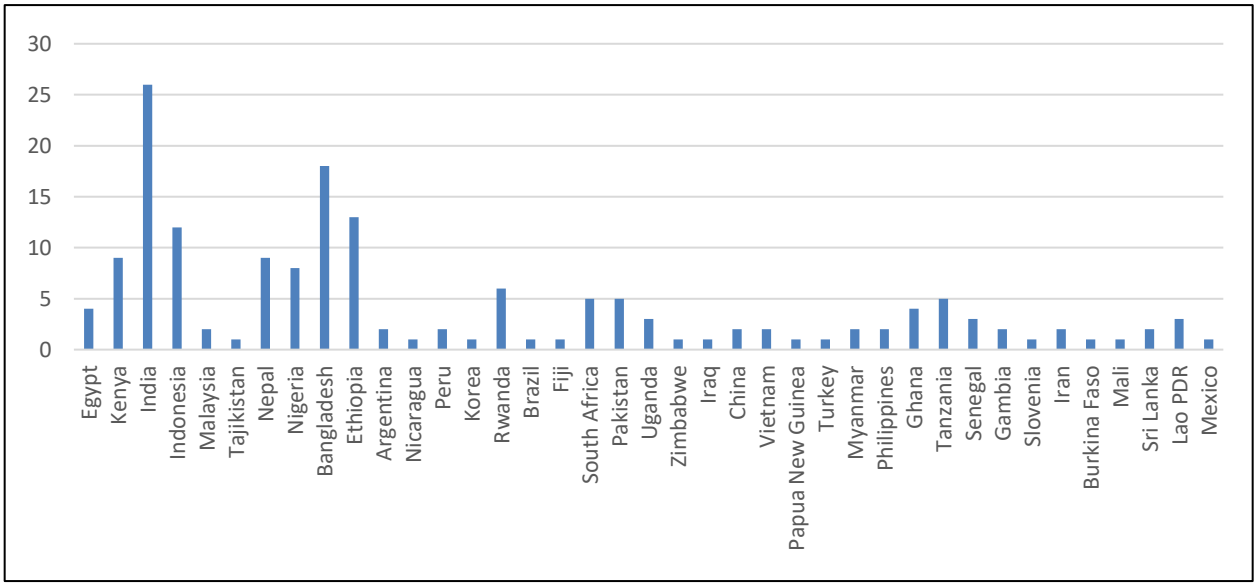
Rural transformation processes carry profound implications for women's overall wellbeing, extending beyond income and productivity to encompass health, safety, and quality of life. This section examines the specific barriers that constrain women's wellbeing within these processes, and the pathways through which transformation can support more holistic gains.

Barriers Faced by Women in Enhancing Well-being

Women's wellbeing in rural transformation is not just about economic growth or agriculture. It is affected by three constraints: limited access to healthcare, restricted control over resources, and cultural norms that affect mobility and decision making. These constraints reinforce each other, trapping women in poor health and food insecurity. For example, ethnic minority women in Vietnam have high childbirth rates but inadequate prenatal care due to transportation costs, language barriers, and the need for male accompaniment (Lotwel et al., 2021). These issues are common in South Asia, where traditional beliefs requiring male chaperones limit access to healthcare for women (Akram, 2018).

Women in rural areas are affected by limited control over agricultural resources by restricted access to resources such as fertilizer and extension services. Women often lack financial capital and are bypassed by extension services due to gender bias and household duties. In rural Sub-Saharan Africa, limited land control restricts crop diversity and causes food insecurity (Egger et al., 2022). Women's limited access to agricultural inputs leads to nutrient-deficient diets (FAO, 2023). Agricultural extension services are male-biased, focusing on women's household roles and thus limiting yield improvements (Biswas et al., 2022), a barrier undermining sustainable food production. Exclusion from technical training delays adopting sustainable practices such as pest management, crop rotation, and soil conservation. Transitioning to sustainable agricultural systems is delayed without equitable access to climate-resilient and ecological farming techniques. Cultural norms, particularly patriarchal traditions, restrict women's access to

Figure 4. Geographical Distribution of Case Studies in Developing Countries



education and healthcare and prioritize sons' education, and domestic duties pull girls from school early. Women lack decision-making autonomy in healthcare and fund allocation. As shown in Table 1, traditional South Asian beliefs frequently discourage women from seeking outside healthcare, especially when male accompaniment is required (Akram, 2018).

Thirty identified barriers in the surveyed literature fall into four domains: economic (credit, land, technology), socio-cultural (patriarchal norms, mobility limits, time poverty), institutional (discriminatory laws, weak services), and psychological (low confidence, lack of awareness). These domains reinforce each other: time poverty (socio-cultural) worsens wage disparities (economic), limiting women's ability to challenge discriminatory laws (institutional). Table 1 lists all barriers, with time poverty, land tenure insecurity, and wage discrimination especially significant.

From Barriers to Empowerment: Rethinking Well-Being

Previous studies reveal that wellbeing improves when interventions address multiple constraints simultaneously. For instance, access to land alone is insufficient. A study in sub-Saharan Africa showed that equal land access for women increased yields by 20–30% but only with additional investments in extension/technical services, access to credit and legal literacy (Njuki et al., 2025). Without these, women with land titles lacked the knowledge or status to use land effectively. Similarly, women's empowerment is linked to household nutrition improvements. When women control food production, nutrition improves as they prioritize children's dietary needs, not because they are more nutrition-conscious, but because they control resources (Rola-Rubzen et al., 2024). This suggests that resource transfers to women without enhancing decision-making authority may not meet nutritional goals.

Technology presents a mixed picture. Digital literacy programs in Kenya have successfully provided rural women with tools to access health information, improving their ability to navigate health challenges (Sánchez-Riofrío et al., 2024). However, it has been found that technology adoption alone, without changes in gendered labor division, rarely reduces women's time poverty. Simply giving a woman a smartphone does not automati cally give her the time or resources to use it. This tension between technological potential and social reality recurs throughout the literature and will be explored further in the following sections.

Policies to Enhance Women's Well-Being

Improving women's well-being is linked to socio-economic interventions, including food security, diet quality, and health. Nutrition and women's empowerment policies show promise across regions. In Bangladesh, training women in vegetable gardening improved household nutrition and income control (Rola-Rubzen et al., 2024). Similarly, Ethiopia's land rights program for over two million women enhanced vegetable production and resource agency (Diiro et al., 2018). Women Farmers Groups (Kelompok Wanita Tani) in rural Indonesia enhance food security by increasing women's control over agriculture and income: Control over agriculture is achieved through direct involvement in food production activities, while control over income comes through women's groups organizing collective marketing of agricultural products, which channels earnings directly to members rather than through male-headed household intermediaries (Mudatsir & Sumarni, 2025). To empower women in food production impacts household nutrition (Prihatiningtyastuti, 2020). Such initiatives provide women with tools to improve family health (Mutiara et al., 2022). Access to women's healthcare, especially reproductive services, is crucial. In regions with healthcare barriers, enhancing reproductive health services can be transformative (Anderson et al., 2021). In Ethiopia, reforms to maternal and child health access have improved outcomes for rural women and children (Bhorse et al., 2024). Women's wellbeing in rural transformation depends less on economic growth and more on investments in healthcare access, nutrition-sensitive agricultural policies, and domestic labor redistribution.

Participation of Women in Rural Transformation

Transforming rural areas for women involves removing barriers to their agency and decision

Table 1. Barriers to Women in Rural Transformation

No.	Barriers to Women in Rural Transformation		
1	Gender-Specific Challenges Women face unique challenges in labor force participation that require targeted policy beyond general economic measures (Islam et al., 2022).	16	Economic Dependency Women often work informally or unpaid on family farms, limiting their household decision-making power, as they usually work only to meet basic needs and lack economic empowerment (Akram, 2018).
2	Limited Access to Resources Women often work informally in family farming, thereby limiting their household decision-making power, as they are employed solely for basic needs (FAO, 2023; Mutiara et al., 2022; Njuki et al., 2025; Rola-Rubzen et al., 2024).	17	Employment Opportunities Women face barriers accessing paid employment. Societal perceptions against women working outside the home and safety concerns about transportation and workplace harassment limit opportunities. (Akram, 2018).
3	Cultural Norms and Social Norms Gender roles and cultural norms restrict women's engagement with technology, discouraging digital literacy and limiting opportunities. Taboos prevent women from seeking employment outside homes (Akram, 2018; Chimerah, 2018; FAO, 2023; Kumar et al., 2024; McGuire et al., 2022; Mutiara et al., 2022; Rola-Rubzen et al., 2024).	18	Awareness of Rights Due to limited education many women are unaware of their legal rights and lack access to the legal system, restricting their self-advocacy (Alemu et al., 2018).
4	Underrepresentation in Decision-Making Women are underrepresented in decision-making, which limits their influence on policy (Pattnaik & Lahiri-Dutt, 2020).	19	Access to Social Networks Lack of supportive social networks hinders women's empowerment. While self-help groups help share experiences, they often face resistance in conservative settings (Bhattacharjee, 2016).
5	Economic Disparities Women have less access to economic resources than men. Female farmers and entrepreneurs face limited access to land and credit, restricting their livelihoods and development. This is the consequence of market failures and institutional biases that favor men (Mutiara et al., 2022). Policies that promote gender equality often fail. They must improve women's ownership rights and correct institutional biases. Women's minimal participation in political decision making limits their power and economic involvement (Chimera, 2018; FAO, 2023).	20	Social and Political Participation While women participate in social and political groups, their influence in decision making may be limited, affecting their ability to advocate for community needs (Mulema et al., 2019). As women take on more agricultural roles due to feminization, they face increased workloads without improved well-being, limiting their economic engagement (Rubzen et al., 2023).
6	Gendered Digital Gaps Significant gender disparities exist in access to digital technology. Women face barriers to accessing digital skills and tools, contributing to a broader divide (Vuciterna et al., 2024).	21	Dependency on Male Labor When husbands work in wage labor, women take on agricultural tasks, becoming overburdened and unable to pursue opportunities (Mutiara et al., 2022).
7	Limited Learning Opportunities Women in rural areas have fewer educational resources and opportunities for digital training, which limits their digital literacy (Kumar et al., 2024).	22	Time Poverty Women face time constraints from household and agricultural duties, hindering their ability to attend training to enhance farming knowledge (Hanafiah et al., 2022).
8	Psychological Barriers Women may experience low confidence in using technology due to societal perceptions and exclusion, deterring them from seeking digital literacy training (Kumar et al., 2024).	23	Wage Disparities/Limited Control Over Income Women earn less than men for the same work. Men earn ₹300–350 (US$3.24–$3.78) daily, but women earn ₹200–250 (US$2.16–$2.70). This gap undervalues women's agricultural work. Although women increasingly engage in paid agricultural and non-farm work, their earnings often go to male household members, limiting financial independence (Singh et al., 2023).

Continued

Table 1 continued

Barriers to Women in Rural Transformation			
	Limited Access to Education and Health Services		Limited Access to Extension Services
9	Girls and women face barriers to education and healthcare. Ethnic minority women in Vietnam often experience childbirth without prenatal care, demonstrating the access limitations (Akram, 2018; Lotwel et al., 2021; Mutiara et al., 2022b; Petesch et al., 2022; Rola-Rubzen et al., 2024).	24	Agricultural extension services show male bias, focusing on women's household roles rather than productive roles. This limits women's ability to improve agricultural yields (Biswas et al., 2022).
	Legal and Institutional Barriers		Increased Workload
10	Discriminatory laws limit women's ability to own assets by restricting inheritance rights to land and property, hindering their economic independence (Akpan, 2015).	25	Rural transformation nevertheless can increase women's domestic responsibilities as they juggle work and household duties, straining their well-being (Rubzen et al., 2023).
	Lack of Supportive Policies		The Feminization of Agriculture
11	Policies that promote gender equality often fail. They must improve women's ownership rights and correct institutional biases. Women's minimal participation in political decision making limits their power and economic involvement (Chimera, 2018; FAO, 2023).	26	As women take on more agricultural roles due to feminization, they face increased workloads without improved well-being, limiting their economic engagement (Rubzen et al., 2023).
12	Resistance to Gender Equality		Religious Barriers
	The agricultural sector resists gender equality and feminist principles, which are crucial for women's empowerment (Njuki et al., 2025).	27	Religious beliefs restrict women's mobility and decision-making. In some Kenyan Muslim communities, women need male accompaniment outdoors, limiting economic activities (Chimerah, 2018).
	Vulnerability in Employment		Limited Access to Finance
13	Women in informal employment face lower wages and job insecurity, limiting their ability to invest in skills or businesses for advancement (Briliyanto & Harsanti, 2022).	28	Gender bias and limited technology access make financing barriers for women traders, hampering market competition and information access (Mohapatra, 2016).
	Impact of Climate Change		Mobility Constraints
14	Climate change significantly challenges rural and indigenous women reliant on traditional agriculture, disrupting practices and affecting livelihoods (Ngo & Tran, 2024).	29	Poor infrastructure in rough terrain, such as in the Hindu Kush Himalaya (HKH) region in Pakistan, restricts women's mobility. Poor transportation and inadequate roads can disrupt trade during adverse weather (Petesch et al., 2022).
	Lack of Technological Adoption		Safety Concerns
15	Women face barriers in agriculture due to limited access to information and resources, hindering their use of technologies that could enhance productivity (FAO, 2023).	30	Violence and harassment deter women traders from formal cross-border trade, leading to a preference for informal markets (Petesch et al., 2022).

making. The Rural Women's Empowerment framework illustrates how transformation impacts women's well-being through employment, income, and empowerment. Agricultural shifts, such as moving to high-value crops and mechanized farming, can alter labor demands, thus easing physical burdens but also increasing time poverty if women manage farms without changing their domestic roles. Non-farm diversification offers alternative income, such as off-farm labor and rural enterprise. However, the ability of women' to seize these opportunities is limited by household duties and cultural mobility restrictions. Transformation impacts empowerment through education, assets, and information access, affecting well-being and food security.

Barriers to Women's Employment in Agriculture

Rural women face significant barriers in employment. Studies in India show that many women farmers perform unpaid labor on family farms, increasing economic dependence on male household members (Akram, 2018), limiting labor market participation. In Kenya, cultural norms confine women to the home, restricting agriculture and paid employment (Tavenner et al., 2019). Women face barriers to formal employment due

to household management expectations. FAO (2023) and Mutiara et al. (2022) note safety concerns, such as workplace harassment in male-dominated industries, vulnerability during transportation to distant labor markets (Akram, 2018), and violence in cross-border trade (Petesch et al., 2022). These concerns tend to confine women to low-wage agricultural work near their homes. A Bangladesh study shows that cultural expectations constrain women's labor migration (Amirapu et al., 2022). When migrating for work, women face additional risks such as harassment and exploitation, hindering their economic prospects (Petesch et al., 2022). These constraints prevent rural women from accessing stable employment outside home.

Time Poverty as a Structural Barrier and the Limits of Technological Fixes

Among the 30 barriers in Table 1, time poverty is uniquely pernicious as it undermines women's health, limits economic participation, and blocks empowerment access. Across South Asia, sub-Saharan Africa, and Latin America, women in rural households spend 10–12 hours daily on domestic chores such as cooking, cleaning, fetching water, and childcare, and the agricultural tasks of planting, weeding, and harvesting. The double burden leaves little time for income-generating activities, skill-building, or community leadership (Hanafiah et al., 2022; Mulema et al., 2019).

Time poverty has gendered roots. The feminization of agriculture, as men move to urban jobs and women manage farms, increases women's workloads without transferring resources or decision-making power (Rola-Rubzen et al., 2023). Female-run households face severe time poverty, due to having to juggle farm and domestic duties by themselves. Exhausted women miss empowerment training and labor-saving technologies, perpetuating time poverty. Can technology help? Evidence is mixed that technology can alleviate time poverty. In Eastern Africa, mechanized tools like motorized threshers reduce women's agricultural task time, allowing them to free up hours for trade or rest (Njuki et al., 2025). In Bangladesh, digital tools that provide market prices and weather updates save time and boost incomes (Sánchez-Riofrío et al., 2024). Despite these promising technologies, a Nepal study indicated that women's work remained high despite time-saving technologies, due to unchanged gender norms (Paudel et al., 2020). Men have not taken on domestic tasks, reallocating the time women saved to additional duties, making technology actually a labor intensifier. This indicates that technology alone is insufficient; interventions must redistribute domestic labor by promoting men's caregiving roles, investing in childcare and water infrastructure, and challenging norms equating women's worth with productivity. Two strategies can help address the problem: infrastructure investments that reduce domestic workload, such as clean water, electricity, and childcare, positively affect women's time; and collective approaches, such as cooperative farming and shared childcare, allow resource pooling and responsibility rotation (Koolwal, 2021; Levien, 2017). Collective efforts create slack that individual households cannot achieve (de Hoop et al., 2023). Both strategies address structural roots of time poverty, rather than just symptoms. In general, time poverty among women is not an inevitable outcome, but rather a structural condition that can be addressed through deliberate policy choices and institutional investment. Where governments and organizations invest in gender-sensitive infrastructure, labor-saving technologies, social norm change, and collective support systems, women's time poverty decreases. Without these, even the best technologies fail to empower. This lesson—that technical fixes need social complements—will recur in the next section on income and empowerment.

Difficulties Facing Women's Income

Income stability is a major issue for rural women in the informal agricultural sector and unpaid farm work. In rural India, women rely on seasonal crops and face income fluctuations hindering investment in sustainable farming. They often perform unpaid or informal labor on family farms, which does not provide enough income (Akram, 2018). This insecurity increases dependence on male household members, limiting decision making over farm inputs, crop choices, and food sales. Women in agricultural work face a wage gap, a disparity salient in male-dominated settings, despite equal contribu-

tions by women (Singh et al., 2023). The wage gap restricts their income stability, with male members often controlling women's wages. Studies from Southeast Asia and Sub-Saharan Africa show rural women entrepreneurs struggle to secure loans due to gender bias in financial institutions (Mohapatra, 2016). Without access to credit, women cannot expand businesses or access better opportunities, perpetuating gender inequality.

Barriers to Women's Empowerment

Women's empowerment is influenced by education access, income and asset control, and gender roles. A study in rural Pakistan showed cultural beliefs prioritize male education, limiting women's education access (Malik et al., 2025). Many rural women lack skills for economic activities or leadership roles (Kumar et al., 2024). Educational opportunities, such as vocational training and agricultural programs, focus on domestic skills over digital literacy or business management, limiting economic empowerment (Akpan, 2015). A study in rural India found women in agriculture receiving lower wages than men, with women earning approximately ₹200–250 (US$2.16–$2.70) per day compared to men's ₹300–350 (US$3.24–$3.78) per day—a gap that undervalues women's agricultural labor, with male household members often controlling their income (Briliyanto & Harsanti, 2022). This financial dependence limits independent decision-making (Singh et al., 2023). Wage gaps restrict women's economic status improvement. Absence of supportive social networks hinders empowerment in conservative cultures (Bhattacharjee, 2016).

Opportunities for Women's Participation in Rural Transformation

Women's participation in rural and urban areas is key to sustainable development, offering socio-structural, economic, and cultural opportunities. Effectively harnessed, participation can address systemic inequities and foster inclusive growth. Consistent with the Women's Empowerment in Agriculture Index (WEAI) framework, opportunities are categorized into five domains: productivity, resources, income, leadership, and time. The domains demonstrate how interventions target empowerment dimensions, with potential to transform women's lives and benefit society (Table 2).

Employment Opportunities for Women

Labor market access is critical for women's economic empowerment. A Bangladesh study shows the impact of increasing employment in non-farming sectors: from 2005 to 2016, women's employment participation increased 10%–28%, labor market identifies the expansion of the ready-made garment (RMG) export sector as a primary driver of rising non-agricultural employment for women (Islam & Islam, 2015). This employment shift has been linked to genuine empowerment gains: Female garment workers report increased economic autonomy, confidence in household decision-making, and self-esteem, though critical constraints including workplace harassment and limited control over earnings continue to limit the extent and sustainability of this empowerment (Al Mamun & Hoque, 2022). However, women's access to agricultural resources remains limited, affecting their productivity (Islam et al., 2022). In rural India, women often work unpaid on family farms. Studies show women receiving training in technical agricultural skills, digital literacy, financial management, and leadership increase productivity and engage in more diverse activities (Armbruster et al., 2019). In Nepal, women using efficient farming technologies, such as mechanized tools and high-value inputs, saw increased profitability. However, due to gendered labor divisions, these technologies did not reduce total work hours. In Kenya, cultural norms prevent women from accessing urban jobs, and migrant women face harassment in male-dominated industries (Petesch et al., 2022). In China, areas with stronger maternity policies have reported higher participation in formal labor markets (Shen et al., 2024).

Time Allocation and Women's Empowerment

Time allocation significantly hinders women's economic advancement. Women in rural areas spend long hours on domestic and agricultural tasks. A South Asian study found that rural women work 10–12 hours daily on household and farm labor,

limiting income-generating activities (Petesch et al., 2022). Labor-saving agricultural technologies can reduce this burden. In Eastern Africa, mechanized farming tools have helped women reduce the time spent on farming, thereby enabling economic activities (Njuki et al., 2025). Interestingly, while digital technologies in Bangladesh reduced time poverty, similar interventions in Nepal failed to do so, suggesting that technology alone is insufficient without shifts in gendered labor norms (Sánchez-Riofrío et al., 2024). In Nepal, despite time-saving technologies, women's work burdens remain high due to entrenched gendered labor divisions that limit women's access to and adoption of the technologies (Paudel et al., 2020). This reflects a broader global pattern: rural transformation does not automatically translate into gender equity without deliberate policy interventions addressing time management and shared responsibilities (Rubzen et al., 2023).

Table 2. Opportunities for Women's Empowerment in Agriculture

No.	Productivity	Resources	Income	Leadership	Time
1	Enhanced healthcare access for women in developing regions correlates with improved productivity and economic participation (Langer et al., 2015).	Equal access to productive resources such as land elevates agricultural yields and mitigates global hunger (Chimera, 2018; Njuki et al., 2025).	Direct access to financial services such as credit enables investments in children's health and education (Chimerah, 2018).	Training programs build women's human capital, enhancing nutrition outcomes and community respect (Chimerah, 2018).	Labor-saving technologies free women's time for market participation (Armbruster et al., 2019).
2	Agricultural technologies boost farming productivity and livelihoods in the Global South (Njuki et al., 2025).	Policy interventions eliminate discrimination in resource access (Armbruster et al., 2019).	Digital literacy fosters economic independence through remote work and entrepreneurship (Kumar et al., 2018).	Farm group participation strengthens social capital in agriculture (Quisumbing et al., 2023).	Maternity leave policies balance work-family demands (Shen et al., 2024).
3	Expansion into garment sectors diversifies women's roles beyond agriculture (Suyatno et al., 2021).	Women's organizations advocate for equal program participation (Rola-Rubzen et al., 2023).	Skill development via vocational training improves workforce competitiveness (Kumar et al., 2018).	Household resource access amplifies women's decision-making voice (Dula, 2019).	Technological tools reduce time burdens in farming (Njuki et al., 2025).
4		Natural resource management leverages women's traditional knowledge for sustainability (Hanafiah et al., 2022).	Networking systems support employment and market access (Ojo & Baiyegunhi, 2023).	Education enhances leadership in cooperatives (Hanafiah et al., 2022).	Legal reforms secure inheritance rights, enabling time flexibility (Arceño & Sarino, 2024).
5			Cooperative memberships overcome barriers to market resources (de Hoop et al., 2023).	Media and nongovernmental organizations (NGOs) raise awareness for rights advocacy (Kumar et al., 2018).	
6			Training in digital skills boosts employability (Sánchez-Riofrío et al., 2024).	Feminist scholarship recognizes women's agency in development (Rubzen, 2024).	
7			Reforms in property rights promote economic autonomy (Shen et al., 2024).	Information access via digital literacy informs decisions (Petesch et al., 2022).	
8			Trade initiatives facilitate market entry (Achatz et al., 2022).	Self-help groups develop entrepreneurial skills (Rola -Rubzen et al., 2023).	

Note: Cells are sequentially assigned to the WEAI dimension that best reflects their primary conceptual alignment. Items relevant to more than one dimension are classified under the most salient category, while empty cells indicate no additional distinct items were identified for that dimension.

Enhancing the Earnings Capacity of Women

Income stability is essential for women's empowerment in rural areas, where women rely on informal, seasonal work. A study in Bangladesh found that women in the garment industry, a major employer, with increased female employment from 2005 to 2016 (Arceño & Sarino, 2024), earned more stable incomes than those in agriculture (Suyatno et al., 2021). This stability enables women to improve their household's economic conditions and invest in education and healthcare. While the garment sector in Bangladesh has provided a pathway to stable income for women (Suyatno et al., 2021), the same cannot be said for agricultural labor in India, where a 20–30% wage gap persists despite equal productivity. Women often have little control over earnings, as wages are managed by male household members (Singh et al., 2023). Addressing these disparities through policy reforms is critical for improving women's economic independence. A study in Sub-Saharan Africa found that women with access to financial services were more able to invest in businesses, thereby increasing income stability (Chimerah, 2018). Future research should evaluate the scalability of interventions to expand women's access to financial services. This includes assessing tailored financial products, such as credit models that use social collateral and harvest-aligned repayment schedules, to reduce dependence on informal markets. Financial inclusion empowers women to manage their income and invest long-term.

Opportunities for Women's Empowerment in Agriculture

Education and skills development are vital for women's empowerment. A rural Kenya study found that women provided with vocational training expanded their economic opportunities and became more active in household decision making (McKenzie & Puerto, 2021). Digital literacy programs in Uganda have shown how technology enhances women's access to employment and financial services (Sánchez-Riofrío et al., 2024). Furthermore, cooperative memberships, which increase women's bargaining power more than individual interventions, provide women with better market access, helping them overcome barriers through collective action (de Hoop et al., 2023)'. Control over income and assets is critical for empowerment. In South Asia, women's access to land ownership rights has improved their financial independence and decision-making power (Akpan, 2015). Women with property rights have the ability to secure loans and start businesses (Shen et al., 2024). Cultural barriers, however, remain challenging. In Kenya, patriarchal norms have restricted women's access to land, even as primary agricultural workers (Padmaja et al., 2020). Legal reforms that ensure women's property rights would help secure their economic futures. Studies by women's organizations in rural Africa, such as agricultural cooperatives in Uganda and Self-Help Groups (SHGs) in Ethiopia, show that including women in decision making leads to equitable outcomes in agriculture and resource management (Pattnaik & Lahiri-Dutt, 2020. These organizations help women advocate for their rights and pressure governments to implement inclusive programming. To expand, they need resource pooling, responsibility rotation, and funding to overcome household constraints. Collective action through memberships significantly strengthens women's bargaining power and market access compared to individual interventions (Fay et al., 2023).

Implications for Policy and Practice

The 30 policy interventions in Table 3 share a common weakness: Most are designed to address single barriers in isolation. Yet the evidence synthesized in this review points to a different conclusion—effective policy must treat gender inequality as a system of mutually reinforcing constraints rather than a collection of independent problems. We distill the literature into three cross-cutting policy priorities, each with concrete mechanisms and caveats.

Policies to Support Women's Employment

Policies improving women's access to diverse employment opportunities are fundamental for gender equality in the labor market. In Ethiopia, family law reforms have empowered women with the legal right to work outside the home. This reform, requiring both spouses' consent to administer family property, has enabled women to engage

in off-farm employment (Mulatu, 2020), enhancing women's economic autonomy and contributions to household income. Programs promoting women's entrepreneurship and access to formal labor markets are key to addressing gender inequalities. Conditional transfer programs targeting women in sub-Saharan Africa have improved their labor market participation by supporting educational and health needs. In Uganda, these programs have increased women's participation in formal labor markets (Diiro et al., 2018). Policies should target the structural barriers women face. Market access can be improved through initiatives such as border markets and international fairs. Policies should pro-

Table 3. Policies for Women's Empowerment in Agriculture

No.	Policies for Women's Empowerment in Agriculture		
1	Understanding Specific Issues Policymakers need to understand issues in order to design effective interventions. Developing tools to address barriers to women's nutrition and empowerment is essential. Policies using household-level approaches can promote gender equality (Kelkay, 2022).	16	Reconciliation of Legal Systems In countries with multiple legal systems, aligning customary and statutory laws is crucial. Laws that comply with constitutional rights can eliminate inconsistencies that disadvantage women's economic autonomy (Akinola, 2018).
2	Conditional Transfer Program Policies should focus on reducing gender inequalities by promoting girls' education and women's health interventions. Conditional transfers to women have improved education, health, and nutrition (Diiro et al., 2018).	17	Mentoring and Training Programs Mentoring and training initiatives help women develop the skills and confidence necessary for leadership roles, thereby supporting their career advancement (Njonge, 2023).
3	Influencing Economic Incentives and Social Norms Policies shape economic incentives and social norms that determine women's labor force participation, types of work, and pay (Tiwari & Joshi, 2016).	18	Leadership Development The development of policies on women's leadership skills is crucial, including training programs for decision-making roles (Nurdin, 2022).
4	Gathering Sex-Disaggregated Data Sex-disaggregated data are crucial for policy design, helping to understand gendered impacts and ensure employment quality for all (Heckert et al., 2021).	19	Regular Reviews of Gender Equality Efforts Governmental bodies, agricultural cooperatives, and development NGOs should review gender equality policies and frameworks regularly to align with women's empowerment goals (Mutiara et al., 2022a; Ngo & Tran, 2024).
5	Promoting Decent Work The United Nation's "Decent Work" agenda focuses on employment, social protection, labor standards, and social dialogue to achieve productive employment for all (Christiaensen & Maertens, 2022).	20	Gender-Transformative Approaches Gender-transformative approaches are vital for changing social norms. They are cost-effective but need development for large-scale implementation (Kristjanson et al., 2017).
6	Inclusive Digital Literacy Programs Governments should develop programs providing digital skills training for women to ensure equal access to technologies and the internet, bridging the gender digital divide (Shenbei et al., 2023).	21	Education and Training Gender-transformative messaging can shift societal norms. Training programs that address gender stereotypes and promote women in agriculture are vital. Policies to expand women's education access through scholarships and safe institutions are essential (Bhandari, 2017).
7	Providing Access to Technology Policies should ensure gender-inclusive digital access by providing affordable internet access and devices to rural women, enabling digital participation (Issa, 2019).	22	Involvement of Men Encouraging men's involvement in caregiving and household duties can redistribute gender roles, improving gender relations and women's empowerment (Theeuwen et al., 2021).
8	Awareness Campaigns Campaigns to raise awareness about women's empowerment and digital literacy can change societal attitudes and encourage support for women's participation in digital spaces (Wulandari et al., 2017).	23	Inclusive Policy Design Policies must target gender equality and women's empowerment. Despite inclusive policy designs, implementation is challenging. Policies should integrate gender perspectives into rural development by ensuring women's access to resources, markets, and decision making, empowering them economically and socially (Andersson et al., 2022).

Continued

Table 3.

No.	Policies for Women's Empowerment in Agriculture		
	Targeted Interventions		Economic Empowerment Programs
9	Initiatives should promote women's digital skills acquisition, including NGO and community partnerships to deliver rural women-tailored training and resources (Chintakindi, 2019).	24	Programs supporting women's entrepreneurship with microloans, business training, and networks can boost women's economic status. Low-interest, collateral-free credit and social protection help women entrepreneurs mitigate trade risks (Abbott et al., 2015).
	Infrastructure Improvements		Health and Reproductive Rights
10	Enhancing infrastructure, such as access to water and electricity, can reduce women's time spent on domestic work, thereby increasing their labor force participation. (Levien, 2017).	25	Access to healthcare, including reproductive services, is vital for women's empowerment. Policies should prioritize healthcare and education (Bhorse et al., 2024).
	Childcare Services		Community Support Programs
11	Providing affordable childcare services, such as Mobile Creches in India, supports women in the informal sector, helping them balance domestic duties with work, enabling fuller workforce participation (Koolwal, 2021).	26	Community programs and women's groups, such as Selembar Daun in rural Indonesia, facilitate collective action and provide training in agriculture, business, and leadership to increase women's control over income (Mutiara et al., 2022a).
	Property Rights		Equal Pay for Equal Work
12	Legal reforms securing women's property rights are fundamental. Eliminating discriminatory laws allows women to control assets and gain independence. Women's rights to agricultural land affect empowerment and food security. In matrilineal societies such as Nagari Indudur in West Sumatra, Indonesia, policies should ensure that women inherit property (Mutiara et al., 2022).	27	Implementing equal pay for women who perform the same work as men is crucial. Despite anti-discrimination clauses, women continue to face wage discrimination. Addressing this gap can improve women's economic status and agricultural participation (Singh et al., 2023).
	Employment Rights		Encouragement of Women's Participation in Governance
13	Legal frameworks that support women's entrepreneurship by expanding access to credit and simplifying business registration can facilitate their entry into businesses and enhance their opportunities (Mulatu, 2020).	28	Policies should facilitate women's participation in governance to ensure that their needs are addressed in community plans (Mulyoutami et al., 2012).
	Legal Frameworks for Business		Incorporation Into Formal Businesses
14	Legal frameworks that support women's entrepreneurship by facilitating access to credit and business registration can streamline startup processes and enhance economic opportunities (Kasim et al., 2024).	29	Policies should integrate female traders into formal businesses, especially in high-value sectors such as horticulture, livestock, fisheries, and non-farm enterprises. This helps women access better resources and markets (Njonge, 2023).
	Protection Against Discrimination		Systematic Dialogues
15	Legal reforms against workplace discrimination create equity and encourage women's workforce participation through legal recourse (Addinsall et al., 2023).	30	Dialogue between border agencies and countries can address bureaucratic challenges women traders face at borders (Pécot et al., 2024).

mote financial products such as low-interest, collateral-free credit, and microloans with flexible repayment. Training barriers can be addressed through vocational programs and digital literacy initiatives, equipping women with the necessary skills for agri-food leadership.

Policies Reducing Domestic Burden for Women

The reconciliation of domestic duties with income-generating activities involves various factors beyond infrastructure. Improved electricity and water services reduce time on chores, increasing workforce participation. For example, electrification in rural sub-Saharan Africa boosts women's

labor force involvement by reducing time spent on firewood and water collection (Koolwal, 2021; Levien, 2017). However, these benefits vary, and depend on factors such as cultural norms, childcare availability (e.g., India's Mobile Creches), task-sharing cooperatives, and technology adoption, which without normative changes may increase workloads. Future research should employ intersectional longitudinal designs to examine how age, ethnicity, and household structure influence infrastructure interventions across regions. These studies should include evaluations of digital tools and green innovations aimed at reducing time poverty. At the policy level, global interventions should expand gender-responsive infrastructure through frameworks like the Sustainable Development Goals (SDGs) and the FAO '2026 International Year of the Woman Farmer. Infrastructure investments must include legal reforms of property rights, gender data monitoring, and partnerships among governments, NGOs, and cooperatives to ensure systemic change.

Policies to Increase Women's Income

Income instability challenges rural women due to reliance on seasonal agriculture and informal labor. Unlike urban or non-farm industries which offer stable, year-round wages, rural agricultural work fluctuates with harvest cycles and weather. Additionally, mobility and safety constraints limit women's access to urban labor markets, perpetuating economic dependence. Policies that enhance women's access to income-generating opportunities are crucial for economic empowerment. Microfinance has been pivotal in improving women's income stability. The Grameen Bank in Bangladesh, for example, has provided small loans to rural women, enabling them to start businesses and improve their incomes (Grameen Bank, 2026). This model has a positive impact on countries such as Bangladesh, Kenya, Ethiopia, and Ecuador (Abbott et al., 2015; Chimerah, 2018; Mulatu, 2020; Sánchez-Riofrío et al., 2024). Tailored financial products, such as micro-loans with flexible repayment aligned with harvest cycles, have enabled women to start businesses and stabilize household income.

Long-term success requires removing barriers like limited market access. Policies must secure property ownership and income growth to enhance women's economic independence. Legal reforms granting women equal land rights, as in Ethiopia, enable investment. As in the production of candlenut oil in Indonesia's Nagari Indudur, policies should protect traditional female property rights (Mutiara et al., 2022). Financial institutions should offer micro-loans with social collateral and flexible repayments to reduce informal market dependence. Financial stability can be bolstered through cash transfer programs, simplified business registration, and gender audits to address wage disparities (Akinola, 2018). Secure property rights enable women to invest in agriculture and businesses, leading to sustainable incomes. Policies enforcing equal pay and transparency are essential. Gender audits in countries like Uganda have helped address wage disparities (Singh et al., 2023). Legal reforms granting women equal rights to own, inherit, and control land and assets enhance economic independence. In matrilineal societies, like regions of Indonesia, reforms ensuring women's property rights have increased economic security and autonomy (Mutiara et al., 2022)

Policies for Women's Empowerment in Agriculture

Macro-level policies should address employment rights and wage parity. Despite equal pay laws, wage gaps of 20–30% persist in agriculture in India, Bangladesh, and sub-Saharan Africa (McCarthy & Kilic, 2015; Singh et al., 2023). Effective measures include payroll audits, wage transparency, and minimum wage enforcement (Arceño & Sarino, 2024; Suyatno et al., 2021). Policy must harmonize legal systems and provide affordable paralegal services. Gender-responsive infrastructure reduces women's time poverty. Electrification in rural sub-Saharan Africa increases women's labor force participation (Koolwal, 2021; Levien, 2017). However, infrastructure alone is insufficient. In Nepal, time-saving agricultural technologies did not reduce women's work hours due to unchanged gender norms, indicating the need for norm-changing interventions with infrastructure projects (Rola-Rubzen et al., 2023). For example, Mercy Corps' BRIGE program in Nepal used a "house-

hold dialogue" curriculum, a facilitated intervention pairing married couples to jointly reflect on and renegotiate the gendered division of labor in their households. This was found to increase women's participation in household and community decision-making (Mercy Corps, 2018).

Agricultural extension services need gender mainstreaming. Women farmers often miss training due to scheduling conflicts or male-focused sessions (Biswas et al., 2022; Mulema et al., 2019). Reforms should include quotas for female agents, gender-sensitive curricula, mobile platforms in local languages, and participatory video approaches. For example, the Ethiopian Digital Literacy Initiative trains rural women to use tablets, though impact evaluations are pending (Shenbei et al., 2023). Collective action institutions such as SHGs, cooperatives, and women's farming groups are called for. Women's cooperative membership enhances market bargaining, peer learning, and access to bulk purchasing (de Hoop et al., 2023; Quisumbing et al., 2023). The Selembar Daun (women' farmers) group in Indonesia exemplifies cooperative initiatives, with rotating leadership and shared labor for organic vegetable production and marketing, training in financial literacy and nutrition, and sustainable farming. Participants report increased income control and decision making (Mutiara et al., 2022).

Digital literacy and financial inclusion are crucial. Mobile money and agent banking improve rural women's access to savings, credit, and insurance, reducing reliance on informal moneylenders (Chimerah, 2018). In rural India, informal lenders charge 12–150% annual interest, compared to 6–20% from formal banks (Hoffmann et al., 2021). However, women in low-income countries are less likely to own smartphones or use mobile internet (Deichmann et al., 2016). Policies should include subsidized devices, digital skills training, and gender-targeted financial products.

Conclusion

Despite adhering to a rigorous protocol, this study has limitations. The literature search used only Scopus and Web of Science for articles 2015–2025, possibly excluding relevant "grey literature" or insights from emerging, unindexed journals. Restricting publications to English may have omitted significant regional research in languages such as Spanish, Portuguese, or French. The focus on South Asia, sub-Saharan Africa, and Latin America limits the generalizability of the findings to other developing regions with different sociopolitical dynamics.

This review of 166 studies reveals the global shift in agriculture management toward women as men migrate to urban markets. This shift occurs within constraints like time poverty, land tenure insecurity, and wage discrimination, marginalizing women. Addressing these issues is a strategic necessity; implementing gender-transformative infrastructure and legal harmonization, as in Nagari Indudur, can boost agricultural output by 20–30%. Meaningful change requires moving from symbolic acts to concrete strategies securing property rights and enforcing equal pay, ensuring that rural transformation strengthens food systems and provides a sustainable future.

This systematic review synthesizes the literature on barriers to the participation of women. Persistent barriers such as unequal access to resources, education, and decision-making, along with patriarchal norms, can be overcome by implementing gender-transformative policies that ensure equal access to resources and strengthen women's agency. The contribution of this study lies in its systematic synthesis of barriers that hinder women's potential. The present analysis offers insights for policymakers designing gender-sensitive interventions. The findings emphasize holistic approaches that address the root causes of gender disparities. 'Women can be empowered to drive rural transformation through targeted interventions that address the structural barriers to their participation. The most effective strategies include ensuring equal access to productive resources, such as land, credit, and agricultural inputs; expanding access to training, extension services, and digital literacy; promoting cooperative farming and women's organizations; and implementing gender-transformative policies that strengthen women's decision-making power. Ultimately, transitioning from fragmented interventions to holistic, inclusive rural strategies that secure property rights and enforce equal pay is fundamental to achieve resili-

ency. Furthermore, these strategies directly address pressing global issues, including chronic food insecurity, rural poverty, and climate change.

Policymakers must prioritize gender-responsive infrastructure and community initiatives. Partnerships among governments, NGOs, and communities can foster environments in which women are change agents. Empowering women in rural transformation is both a moral and strategic necessity. By dismantling barriers, stakeholders can unlock the transformative potential of women. While this review highlights critical empowerment pathways, future research must shift from broad assessments to nuanced, localized studies. An intersectional, holistic lens should examine how age, ethnicity, and marital status interact with gender to affect resource access, especially for rural youth. Longitudinal research is needed to track the socioeconomic impact of legal reforms, such as family law and land inheritance, on women's decision making in households. In addition, future inquiries should assess the efficacy of digital agricultural tools in reducing time poverty, exploring whether technology adoption alters domestic labor division or simply increases workloads. Finally, with the move toward sustainable food systems, research should examine the roles of green innovation and circular economy practices in creating formal employment for women beyond low-wage agricultural work.

To effect meaningful change, stakeholders must shift from isolated fixes to aligning policy and social norms. This involves prioritizing gender-responsive infrastructure, such as clean water and affordable childcare, such as India's Mobile Creches, to reduce women's burdens. Technology, such as the Ethiopian Digital Literacy Initiative tablets, is insufficient without community dialogues and action groups like Selembar Daun that challenge patriarchal norms. Empowering women is vital for resilient global food systems. Moving from symbolic declarations to strategies that secure property rights and equal pay is crucial in the 2026 International Year of the Woman Farmer, unlocking the potential of half the world's population.

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A food policy council primer: How food policy councils can be a catalyst for change

Book review by
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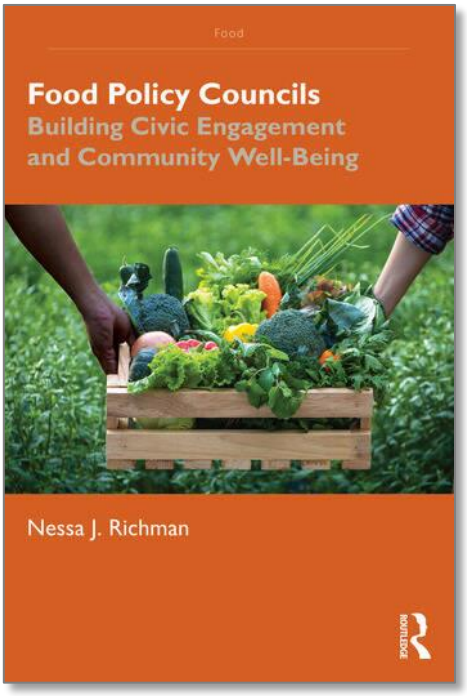

Review of *Food Policy Councils: Building Civic Engagement and Community Well-Being*, by Nessa J. Richman. (2026). Published by Routledge. Available as hardcover, paperback, and eBook 208 pages. Publisher's website: https://www.routledge.com/Food-Policy-Councils-Building-Civic-Engagement-and-Community-Well-Being/JRichman/p/book/9781041125808

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Although food policy councils are not always well understood or appreciated, they can be pivotal tools to improve local and regional food systems. Strengthening local food systems is critical right now, when so many issues can interrupt broader food supply chains and, in the U.S., national support for important systemic issues is in jeopardy. Nessa J. Richman's *Food Policy Councils: Building Civic Engagement and Community Well-Being* is a timely and necessary primer for food systems participants about the creation and running of a food policy council (FPC), and for existing FPCs on how to be more equitable, effective, and even more ambitious in their work transforming local food systems.

The book takes a comprehensive approach, covering everything from the granular issues of starting and running an FPC, to their role in supporting communities and working toward democratic food systems change. Richman shares her valuable expertise and insights gained over years of food systems leadership and as executive director of the robust Rhode Island Food Policy Council

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(RIFPC). She begins with the emergence of FPCs in the early 1980s. The original concept was that bringing together stakeholders would produce a more powerful engine for food systems transformation than working separately. Today, Richman says this collective strength comes from broad and diverse community participation and certain core roles and skills that FPCs share regardless of what form they take. This is helpful framing for readers who are not already familiar with FPCs.

Richman identifies the core roles of convening, educating, and advocating that FPCs use to achieve their chosen policy goals. The core skills underlying these roles include helping people find common ground, fundraising for both the FPC and its participants, and stimulating citizen participation in policy and advocacy. The specifics of how each FPC interprets and addresses these roles and skills vary, but Richman posits that all FPCs should help achieve "food democracy" by working collaboratively with government and inspiring and supporting stronger civic engagement, particularly from voices that are often not heard and who are most affected by food systems inequities. Richman describes this broad participation in democratic processes as an unchanging principle that should guide all FPCs and offers specific guidance for how FPCs can further this.

The book includes chapters with advice on the three substantive areas that many FPCs address: food access and security; food business and economic development; and climate and the environment. However, from a practical standpoint, this book's greatest gift might be the how-to sections on fundraising and evaluation. Richman offers expert guidance, including examples, models, processes, and forms that were successful for the RIFPC and other FPCs, and that can benefit both new and more mature groups. For example, Richman shares the RIFPC's Network Survey, an excellent resource for self-evaluation.

The examples and models provided illustrate how FPCs can better communicate their value to funders and the community at large, a key skill that FPCs need to develop for both fundraising and engagement. That said, even with this skill, acquiring funding for systemic food systems change is no easy task. Many donors and funders focus on the necessary (and becoming even more necessary as the federal government cuts its programs) day-to-day emergency work needed in the food system and are limited by their budgets, biases, and issue area. Even some local governments that fund FPCs under their auspices have explored cutting them from their budgets (Nitta, 2026). The framework and tools Richman provides will go a long way toward helping FPCs navigate today's challenging funding environment and better communicate their added value. This book could also be a resource for first-line food security and climate funders to help them see the value of systems solutions.

While *Food Policy Councils* touches on how internal FPC decisions are often made—collaboratively, with no one right way—another entire book could be written delving more deeply into specific approaches and inclusive practices that can be used to conduct decision-making and support the core skill of bringing people together and navigating differences when deciding on any actions an FPC might take. There can be issues of governance that might need to be addressed in FPCs that are not embedded governmentally about the roles of and relationship between staff and volunteer council participants and stakeholders, with a board if one exists, and among diverse participants. The effectiveness of an FPC rests on achieving a good balance with clear roles for all and keeping participants meaningfully engaged, while also allowing the FPC to move forward with important initiatives.

In the recently released chapter 1 of *Food Policy Councils in Action: Representing the Food System within the Food Policy Councils* (Prota & Reckinger, 2026), a short series of more internationally focused case studies illustrates this and other entwined issues that can bedevil an FPC: how to ensure that the makeup of an FPC equitably reflects the community, how to manage conflict among different points of view, and how to reconcile broad participation with efficiency in the function of the FPC.

The work of both Richman and Prota and Reckinger (2026) highlights the importance of trust and transparency, and wisely advises that the members of the community who are most affected by decisions and who are often least heard should be uplifted and fore-fronted in those decisions. How-

ever, diverse collaborative groups like FPCs need to thoughtfully choose and continually reevaluate their decision-making processes, considering who has power and who does not, how to reconcile differences, and how to balance participation with momentum. Self-evaluation tools, like the network survey Richman shares from the RIFPC, will help with this, but additional work is necessary.

This book should help people feel supported and empowered to begin an FPC or bolster an existing one, harnessing the strength of community to strengthen their local food system. As Richman also contends that strengthening our local food systems strengthens our communities, this can create an impactful feedback loop, with FPCs at the nexus. This book can help more FPCs become that catalyst for positive change, and help others in the food policy, food systems, and funding spaces better understand the value of food policy councils.

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Revaluing waste: Care, recirculation, and food politics in *Truffles and Trash*

Book review by
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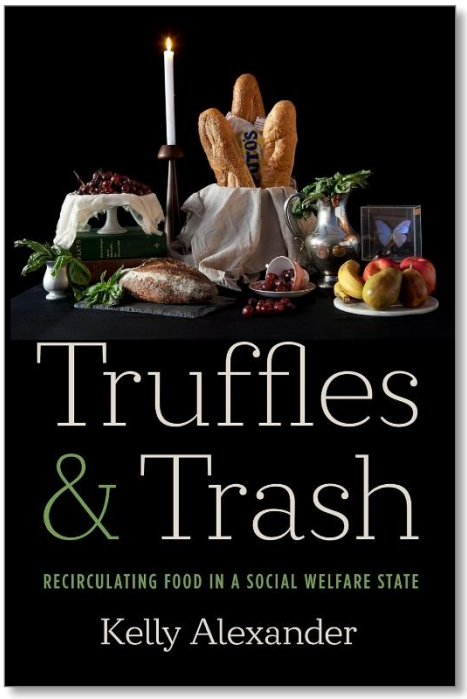

Review of *Truffles and Trash: Recirculating Food in a Social Welfare State*, by Kelly Alexander. (2024). Published by University of North Carolina Press. Available as hardcover, paperback, and eBook 236 pages. Publisher's website: https://uncpress.org/9781469678597/truffles-and-trash

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Kelly Alexander's *Truffles and Trash: Recirculating Food in a Social Welfare State* traces the movement of edible but discarded food through Brussels' expanding network of food-recirculation initiatives. The book enters a global conversation on food waste intensified by the 2011 Food and Agriculture Organization of the United Nations (FAO) report estimating that one-third of food produced for human consumption is lost or wasted. Rather than framing waste as the individual consumer's responsibility, Alexander situates it within the structural logics of capitalist food systems. As she explains, "This project is about innovative and creative ways to recirculate discarded food *before* it becomes food waste, and to do that as a way of caring for other people and for the planet" (p. 41, emphasis in original).

Alexander—an anthropologist and food studies scholar—entered the project curious about how certain foods, especially truffles, acquire extraordinary value—or are overvalued. Her apprenticeship at La Truffe Noire, a Michelin-starred restaurant in Brussels built around one of the world's most expensive ingredients, quickly confronted her with a different reality: the sheer volume of edible food routinely discarded. "I felt ill peering into that bin every day, seeing so much good-looking food

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go uneaten" (p. 12). That encounter became a pivotal moment, shifting her focus from why some foods are prized to how food gains and loses value along a spectrum of edibility. What began as a fixation on waste in one high-end kitchen broadened into a study of food waste across Brussels, exploring how surplus is produced, judged, and redistributed.

She spent the next five years conducting ethnographic fieldwork across three food-recirculation sites in Brussels. Through participant observation, volunteering, and informal interviews, Alexander traces how people and institutions assign or deny value to discarded food. These methods position her to explore the book's guiding questions: When does food become waste? Who decides whether food is still edible: the institution, the consumer, or the state? What are the social, ethical, and political dimensions embedded in this process? These questions anchor the book's three sites, each of which illustrates a distinct mode of recirculation within the Belgian welfare state. Some sites allowed extended immersion in daily operations, while others provided more limited but still meaningful access. Together, these field encounters form a layered portrait of how surplus moves, who can transform it, and what social relations emerge along the way.

Before turning to these sites, Alexander outlines Brussels' unusually fragmented political structure. The city's overlapping linguistic communities, municipal authorities, and European Union (EU) institutions create a dense bureaucratic terrain through which food recirculation efforts must navigate. This context is crucial: recirculation is not only a matter of moral commitment or logistical ingenuity, but also of jurisdictional constraints that shape what services can exist in the first place. Her political-geographic framing makes it possible to understand each site not as an isolated initiative but as operating within—and sometimes pushing against—a thick bureaucratic landscape.

The first site, The Food Bank of Brussels, reveals both the necessity and insufficiency of food-bank infrastructures. Alexander demonstrates how food banks, despite formal neutrality, reproduce charitable logics that differentiate between givers and recipients and subtly police who is "deserving." Her documentation of sorting protocols, eligibility checks, and volunteer oversight illustrates how hierarchy is continually reproduced. The food bank alleviates immediate need, but it does so within a neoliberal welfare model that treats hunger as an individualized problem rather than a political one. While analytically strong, the chapter shallowly touches on how clients navigate or resist these structures. Still, the food bank serves as the book's baseline: a system that redistributes surplus while remaining tethered to the very conditions that produce precarity and waste.

The second site, Bel Mundo, a "social restaurant" using surplus as a primary resource, offers an alternative model. Rather than treating waste as refuse, Bel Mundo reframes waste as "surplus" and thus as productive input, allowing recirculation to function simultaneously as social welfare and partial economic alternative. The restaurant provides affordable meals, workforce development, and community services without relying on charity or discourses of personal responsibility. At the same time, the chapter raises a deeper contradiction: initiatives dependent on surplus redistribution remain structurally reliant on the very systems of overproduction they seek to mitigate.

The final site, Cultureghem, centers on reclaiming unsold produce from Belgium's largest outdoor market and redistributing it through community cooking and mobile soup kitchens. Alexander's attention to ethnographic detail shines here as she captures the improvisation, relational labor, and regulatory tensions shaping open-air food work. Cultureghem transforms waste into a vehicle for creating shared spaces and forms of care beyond formal welfare institutions. Yet the initiative remains precarious as it is dependent on volunteer labor and discretionary tolerance from authorities. Its success underscores the book's central tension: care can flourish in the gaps left by state and market systems, but those gaps are structurally produced and easily threatened.

Alexander's concluding pivot to the United States feels somewhat abrupt. Her brief discussion of Philadelphia's The People's Kitchen gestures toward parallels but stops short of sustained com-

parative analysis. U.S. food-welfare infrastructures operate under weaker safety nets and a more aggressively privatized nonprofit landscape than Brussels, yet the book only briefly acknowledges how these structural differences shape what food-recirculation initiatives can realistically accomplish. The comparative section raises more questions than it answers.

Even with these limitations, *Truffles and Trash* is a valuable contribution to scholarship on food systems and the politics of waste. In a field shaped by dispiriting statistics and individualizing solutions, Alexander offers a hopeful perspective. Her ethnographic attentiveness, paired with her strong understanding of political geography, makes the book especially useful for readers interested in the labor required to revalue discarded food. Ultimately, *Truffles and Trash* shows that small, grounded interventions can generate social, economic, and civic benefits far beyond the meal itself. The act of seeing value in discarded food can foster community and create spaces that challenge the systems producing waste. Alexander reminds readers that recirculation is not merely a technical fix, but a social and political practice—one capable of reshaping how care and value circulate in society.

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Africonnections: Seeds of memory, roots of survival

Book review by
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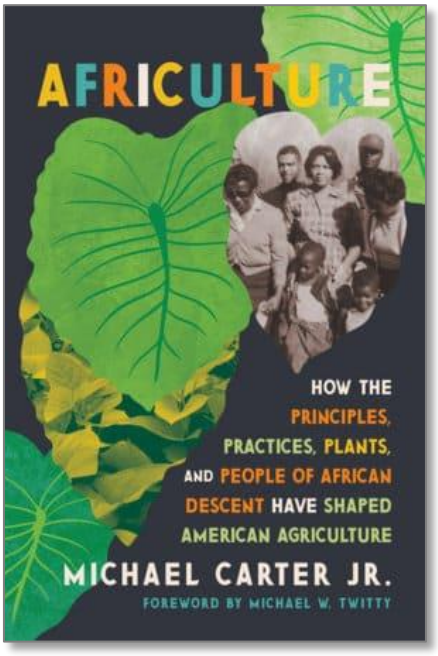

Review of *Africulture: How the Principles, Practices, Plants, and People of African Descent Have Shaped American Agriculture*, by Michael Carter Jr.. (2026). Published by Chelsea Green Publishing. Available as hardcover, Kindle, and audiobook. 336 pages. Publisher's website: https://www.chelseagreen.com/product/africulture/

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Through *Africulture: How the Principles, Practices, Plants, and People of African Descent Have Shaped American Agriculture*, Michael Carter Jr. is building a bridge that many Black, African, and African American farmers, agriculturists, and future generations have long been waiting for—a bridge that makes it possible to see ourselves reflected in agricultural spaces. Myself included. This is not easy work. With the records of those kidnapped and enslaved in the Americas missing, fragmented, or deliberately erased, the work of reconnecting begins with the seeds that traveled here through the hands and knowledge of the enslaved.

The plants that grow in American soil tell a story of violence, but they also tell a story of resilience, fortitude, and deep agronomic knowledge. My ancestors, Carter Jr.'s ancestors, and the ancestors of countless Black Americans came here against their will and endured unimaginable suffering. Yet, through narratives like Carter Jr.'s, their stories live again. They reveal how the knowledge and labor of enslaved Africans shaped American agriculture, even as colonizers refused to acknowledge the depth of their expertise or the fullness of their humanity.

Carter Jr.'s work invites us to reconsider what has been lost, what has survived, and what continues to grow—and it challenges us to recognize

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Black agricultural knowledge as foundational, rather than peripheral to the story of American farming. I encourage you not only to journey through *Africulture* alongside this review, but to open the book yourself and sit with the stories held between its pages.

A blending of memoir, historical recollection, and meditation on past, present, and future, *Africulture* guides readers through the intertwined histories of the Carter family, enslaved Africans, and the agricultural life that shaped Michael Carter Jr. himself. Throughout the book, Carter Jr. returns to the core principles of Africulture, a pedagogy (predating and the basis of the book *Africulture*) he developed in order to educate, connect, and uplift the agricultural knowledge of people of African descent (Africulture, 2026). Rooted in a mission to challenge the stigmas born from the transatlantic kidnapping and enslavement of Africans, Africulture weaves a web linking African crops, folklore, cultural memory, nutrition, stewardship, and generational health. These principles ground the narrative, revealing Africulture not only as a historical framework but as a living pathway toward increasing Black farmers, agrarians, environmentalists, and land stewards. Through Carter Jr.'s storytelling, Africulture emerges as both remembrance and reclamation: a reminder that Black agricultural wisdom is not peripheral, but foundational to the story of American farming.

Rather than offering a linear, chapter-by-chapter history, *Africulture* uses the metaphorical language of plant life—seeds, soil, roots, leaves, fruit—to build an argument about the endurance and brilliance of African agricultural knowledge. Carter Jr. shows that the seeds carried by enslaved Africans were not only botanical but cultural, intellectual, and spiritual, and formed the foundation of agricultural practices in the Americas. By tracing how people and plants adapted, suffered, resisted, and flourished across generations, he demonstrates that Black agricultural identity is not a relic of enslavement but a living inheritance. The book's structure reinforces this point: each stage of plant growth becomes a lens for understanding how African-descended people have been uprooted, transplanted, composted, and encouraged to leaf and fruit again despite systemic barriers. Through personal narrative, historical reflection, and the principles of Africulture, Carter Jr. argues that reclaiming this heritage is essential for increasing the number of Black farmers, strengthening community health, and challenging the persistent stigmas that distance Black Americans from agriculture. In this way, *Africulture* succeeds not only as a story of one family but as a call to recognize Black agronomic knowledge as foundational to American farming and vital to its future.

Michael Carter Jr.'s work stands in conversation with a long lineage of scholarship that foregrounds African agricultural expertise, including Judith Carney's *Black Rice* (2001), Peter Wood's research on enslaved labor systems (2024), and Daniel Littlefield's work on African agronomic knowledge (1991). These scholars demonstrate that Africans were targeted during the transatlantic slave trade precisely because of their skill in rice cultivation, irrigation, and seed stewardship—challenging narratives that once framed enslaved people as unskilled labor. More recent studies continue to dismantle these distortions by highlighting the ecological innovations, crop systems, and foodways that enslaved Africans introduced and adapted under conditions of extreme violence. Complementary works by Michael Twitty (2017) and Jason Porter (2025) show how seeds, culinary practices, and ecological knowledge function as cultural memory, preserving evidence of African innovation across generations (see also Carney & Rosomoff, 2009).

Even with this supporting literature, *Africulture* takes on a life of its own. Carter Jr.'s narrative is not simply an academic contribution—it is a lived one. His writing embeds rich history within personal experience, strengthening the book's argument by grounding it in the realities of a Black agriculturalist whose family has carried this knowledge across generations.

If we do not reflect on past inequities, traumas, and erasures, there is no way to move forward. *Africulture* makes clear that the violence of kidnapping and enslavement also carried ecological knowledge, agricultural diversity, and a resilient people whose hands remain in the soil of American agriculture. To fully understand what agriculture in the United States is—and how it came to be—we

must acknowledge and support the descendants of those whose expertise built it. Carter Jr. calls readers to do exactly this: to make space for Black farmers, to recognize their agricultural heritage as foundational rather than peripheral, and to ensure that the next generation of Black agrarians can take up space in fields where their ancestors were once denied humanity. In this way, *Africulture* is not only a book but an invitation to participate in a more honest, equitable, and rooted agricultural future.

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Agroecology is the future of Puerto Rican agriculture

Film review by
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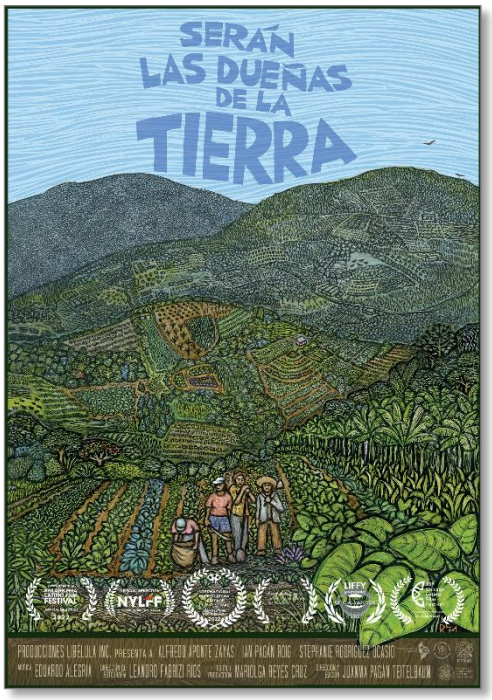

Review of *Serán las dueñas de la tierra* (*Stewards of the Land*) [Film]; JuanMa Pagán Teitelbaum (Director). (2022). New Day Films. 92 minutes; Spanish with English subtitles. Website: https://www.newday.com/films/stewards-of-the-land-seran-las-duenas-de-la-tierra

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The documentary film *Serán las dueñas de la tierra* (*Stewards of the Land*) depicts a struggle that everyone in the U.S. should know about: not just to understand how difficult growing healthy food is, but also to see the consequences of colonialism on our unincorporated territory of Puerto Rico and its corrupt land allocation practices. The film follows three landless farmers in Puerto Rico as they try to obtain and keep farmland. Puerto Rico imports 85% of its food, and one-third of the population is food insecure. Yet it has large amounts of prime, fertile farmland, water, and sun; under other circumstances, it could be feeding all of its people well and exporting produce. Hurricanes have wreaked havoc on its farms over the past eight years (especially Irma and María in 2017), but better preparation and infrastructure might help farmers to retain more of their crops.

As a farmer remarks late in the film,

> You hear a lot of people say that young people don't want to work, especially in … produc-

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> tion. However, there's a resurgence of young people that are interested but have little access to agricultural land. The government closes the doors on them. The Land Authority, which has land to lease, often gives them to private companies. Puerto Rico is the largest seed producer in the world now. But they are foreign companies and don't contribute much to the country's agriculture. All they do is pay starvation wages and pollute our crops.

The three young farmers whom the film follows are indomitable. Ian Pagán Roig at Josco Bravo, a farm and project, says that he has had to start over five times in three years after major hurricanes, drought, and flooding. He is farming a small plot in Toa Alta near where he grew up, and teaching agroecology to multigenerational classes. Stephanie Rodríguez Ocasio teaches middle-school students farming and healthy eating. After losing rented land that she fought to obtain, she makes an arrangement with a sympathetic landowner who wants to help young farmers to access land. She continues to teach young people, however. Alfredo Aponte Zayas, whom we first see in the U.S. shoveling snow, moved to Puerto Rico to farm after getting a PhD in 2016. Securing land from the Land Authority took a long time, but he finally was able to plow and plant his field. Hurricanes wiped out his entire crop and he fell behind in land payments. Rather than granting a waiver, the Land Authority evicted him; his farm has been abandoned ever since. Since he had a family to support, he ended up getting a job as a forage specialist with the U.S. Department of Agriculture (USDA). In the film, we see Alfredo meet with the local Land Authority director and point out that failing to support and educate young farmers is totally against the Land Authority's lofty mission to advance Puerto Rican agriculture. It seems clear that staff people in the Land Authority are being paid off to give contracts to foreign companies, and the farmers feel helpless. Alfredo wonders if they might join together in a movement, but for now they are under the boot of the Land Authority.

I was lucky to be able to visit Josco Bravo in 2024 and was thoroughly impressed with Ian's dedication to growing more food for Puerto Ricans and teaching others how to start farms. This is unmistakably conveyed in the film as well: he has become almost legendary through the students who have worked with him. He learned farming as he was growing up, then got an undergraduate degree in soil science and a master's degree in soil restoration with organic practices. His comment on the university system is that departments of agronomy produce agronomists, not farmers. Although I visited after the Land Authority had tried to evict him following Hurricane María, he was focused on just getting on with his work instead of recriminations. Donations from outsiders prevented the eviction, and since 2017 Josco Bravo has produced at least 80,000 pounds of food and taught over 300 aspiring farmers.

It is infuriating to me, as a U.S. citizen, to see how young farmers are undermined by the Puerto Rican Land Authority. Young farmers like Ian and Stephanie should be receiving abundant government support and good salaries for what they are doing, not spending their time trying to simply keep their land. Ian pointed out in the film that, because of their soil conservation practices, they had good topsoil even after the hurricanes, unlike other farmers whose soil washed away. Erosion is a huge problem all over Puerto Rico; the government is ignoring some of the best ways to keep soil, as well as ways to reduce food insecurity and dependence on food imports. Meanwhile, most people in the mainland U.S. see Puerto Rico as a playground of beaches and the quaint little streets of Old San Juan. *Stewards of the Land* can help to raise awareness of another side of Puerto Rico.

This film would be appropriate for students from middle school through undergraduate studies. Ideally, it would be accompanied by discussion of colonialism, Puerto Rico's fight for autonomy from Spain and the U.S., and differences between agroecology and industrial agriculture. The farmer helping Stephanie says at one point that almost all of the farmers using industrial agriculture had died of cancer, but those farming without synthetic pesticides had healthy lives. Stephanie's students sell the produce they have raised from door to door, and one calls out "Chemical-free lettuce!" to entice more customers after one customer does not know what "organic" means.

The film is a bit choppy, jumping from one story to another, but the viewer can piece together the stories of the three courageous farmers by the end. There is very little political commentary, although we see the infamous footage of Donald Trump tossing rolls of paper towels into an audience of people who had lost everything in Hurricane María. It is obvious that food aid at the time was insufficient. For people who have lost their homes and belongings, agroecology offers a hopeful way of becoming self-sufficient for food. This film demonstrates the deep resilience of the Puerto Rican people despite multiple adversities.

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Agricultural knowledge, place, and production in *The Almond Paradox*

Book review by
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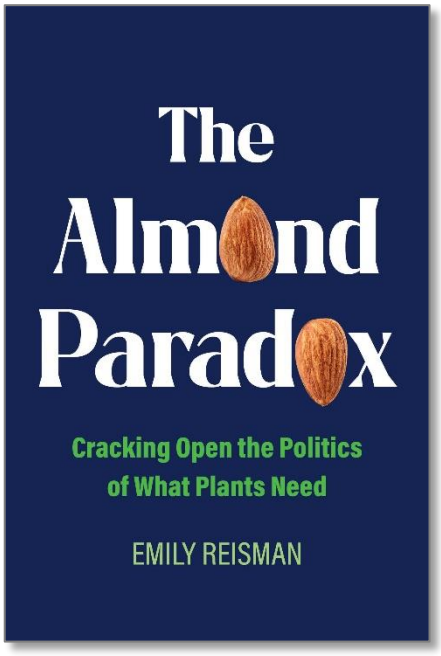

Review of *The Almond Paradox: Cracking Open the Politics of What Plants Need*, by Emily Reisman. (2025). Published by University of California Press. Available as hardcover, paperback, and eBook 186 pages. Publisher's website: https://www.ucpress.edu/books/the-almond-paradox/

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Almonds are a controversial crop in the U.S.; many decry the trees' thirst in water-stressed California, where most global almond production occurs (Gonzales, 2015; Palmer et al., 2024; Pollan, 2007; Reisman, 2019). But this is only part of the story. Emily Reisman examines how different agricultural, political, place, and environmental contexts shape our understanding of what almond trees "need," comparing intensive almond production in California with Spain's traditional rainfed systems in her 2025 book, *The Almond Paradox: Cracking Open the Politics of What Plants Need.*

Dramatic increases in almond production have also led to steady, higher demand for the product, fueled by marketing investments from the grower association. Almonds are no longer a seasonal holiday food and instead are eaten year-round with many uses. These market demands have shaped almonds as a major agricultural crop in California's Central Valley, creating new challenges for food and environmental systems.

The comparative framework between the U.S. and Spain outlines opposite approaches to water use, pollination, and environmental sustainability as the book delves ever deeper into why agricultural decision-making matters and the impacts those

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decisions have on the entire food system. As Reisman explains,

> Rainfed growers relying on almonds to fill a niche in a more complex landscape and livelihood prioritize resilience. Their practices are rooted in pragmatism. Capitalist agronomic knowledge strives to identify every possible deficit or stress but remains unable to see a plant's strengths. Given the right social conditions, a plant notorious for being thirsty can just as easily be championed for its thrift. (p. 73)

Using the premise that almonds are not inherently "thirsty" or pollinator-dependent, Reisman offers a compelling examination of how agricultural knowledge is constructed, challenging assumptions about almond production while raising important questions about sustainability, science, and political economy. She addresses such key themes as political ecology, agriculture knowledge production, capitalism and food systems, environmental sustainability, and the relationship between science and policy. As she summarizes,

> How much water almonds "need" is less a function of flows through plant tissues than flows of capital. The upward creep of the crop water requirement demonstrates how a seemingly stable agronomic fact is in reality a reflection of increasingly intensive practices designed to maximize returns. (p.72)

Pollination is another example of an agronomic fact being shaped by the place and production system. Reisman and Pollan (2007) explain that California imports bees from all over the U.S. and overseas each February to pollinate almond trees. The impacts include disrupting the bees' seasonal cycle, introducing parasites and pathogens into their hives, and increasing the environmental load as hives are hauled in each year. The beekeepers become economically tied to almond production as a source of income. In Spain, on the other hand, almond orchards are able to rely on native pollinators and local beekeepers.

Capital flow shapes production practices and is influenced by agribusiness partners and university funding priorities, among others. One challenge Reisman cites is that science uses "values-neutral language." Researchers and extension professionals may also understand the environmental harms of the unsustainable practices in almond production, but their position is complex when the system prioritizes maximizing production over environmental sustainability or other factors. Those creating and disseminating agricultural knowledge have a huge influence on what our agricultural systems have become and is one area where change can begin.

Throughout the book, Reisman challenges assumptions about almond production and demonstrates how agricultural "facts" are shaped by place and context to encourage readers to examine other crops and agricultural facts; the almond is just one example. Reisman shows how the food system is interconnected and connects to current debates about climate resilience, water management, and agricultural sustainability, encouraging readers to examine the food system as a whole, using the almond as the example that the status quo is not necessarily the only solution.

While Reisman contrasts the systems, she does not point to Spain's practices as the ideal solution. There, almonds were traditionally grown as an income diversification strategy on land unsuitable for other crops. Over time, Spain has started incorporating the same intense production practices seen in California. Reisman challenges readers to rethink the food system so that values-based decisions are used in crop production instead of capitalist-based decisions. Academic and other institutions now face more pressure to prioritize sustainability efforts instead of just farm profitability. "Fundamentally, a better future requires a political economic system that favors agricultural forms serving societal needs rather than squeezing farmers between high costs and low prices such that productivism is the only path" (p. 125). A path forward could allow a crop like rainfed almonds in Spain to remain in the margins; Reisman emphasizes the benefits of place-based knowledge and agricultural practices as a path toward greater sustainability.

In *The Almond Paradox*, Reisman echoes many of the concerns raised by Michael Pollan (2007) in his critique of industrialized food systems. Both authors challenge assumptions about efficiency, present the influence of economic and political forces on agriculture, and argue that modern food production often becomes ecologically vulnerable when it prioritizes standardization and growth over local environmental conditions.

The in-depth analysis of the almond paradox expands the agricultural sustainability discussion beyond resource-use metrics and encourages readers to consider how knowledge is created and normalized. This has implications for university research, the Cooperative Extension System, and policy development. Readers and food systems leaders are urged to question assumptions about best management practices using a place-based and values-based perspective. This in turn connects the broader issues facing society, including water scarcity, food systems resilience, and global agricultural development. The larger question still to be answered is defining sustainable agriculture practices so that the word "sustainable" is less opaque and, as Pollan (2007) warns, the current solutions do not become future problems.

Ultimately, *The Almond Paradox* demonstrates that agricultural systems are shaped not only by biology and ecology but also by history, economics, politics, and culture. By revealing how ideas about what plants "need" are shaped as much by social systems as by biological realities, Reisman offers a thought-provoking contribution to contemporary discussions of agriculture and sustainability.

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